omological Society
British Columbia

50th Anniversary Number

PROCEEDINGS

of the

ENTOMOLOGICAL SOCIETY *of* BRITISH COLUMBIA

Volume 48 Issued August 15th, 1952

CONTENTS

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Economic and Systematic Papers pages 36 to 100

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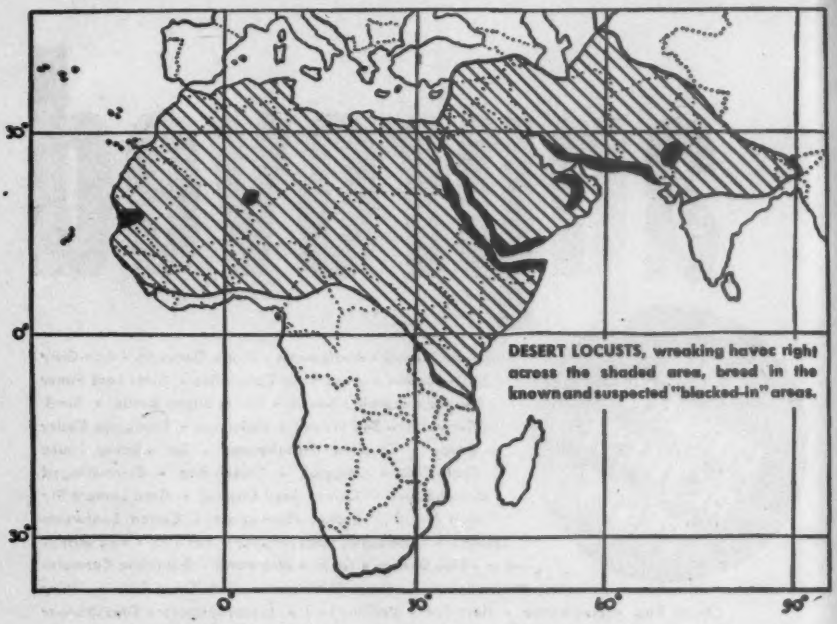

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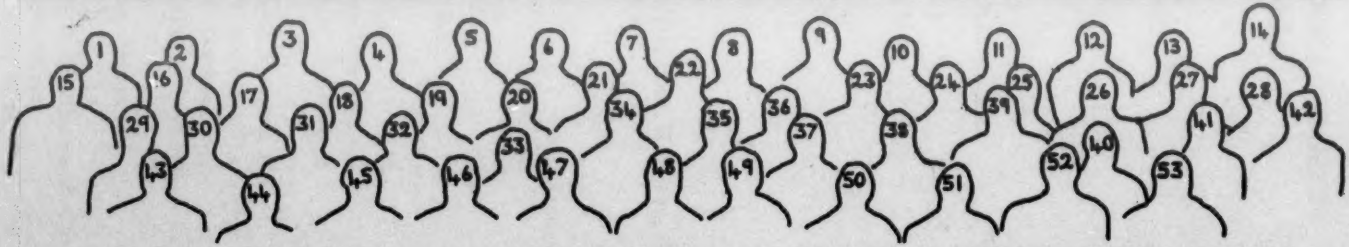

KEY TO GROUP PHOTOGRAPH OF 50th ANNUAL ENTOMOLOGICAL SOCIETY OF BRITISH COLUMBIA MEETING

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7. A. D. Henderson
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14. N. B. Wright
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16. R. Robertson
17. G. Thompson
18. H. R. MacCarthy
19. W. Lazorko
20. D. K. Campbell
21. C. P. Clausen
22. W. Waddell
23. J. W. Eastham
24. D. R. Finlayson
25. K. Graham
26. R. E. Fitzpatrick
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28. J. Follwell
29. H. Richmond
30. L. C. Curtis
31. K. M. King
32. M. C. Lane
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34. H. G. Fulton
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36. J. H. Foster
37. E. R. Buckell
38. D. Arnott
39. O. Hitchcock
40. C. R. Cunningham
41. R. Stace-Smith
42. D. A. Ross
43. G. J. Spencer
44. E. P. Venables
45. M. H. Hatch
46. J. D. Gregson
47. W. A. Ross
48. H. F. Olds
49. J. Marshall
50. J. H. McLeod
51. W. Downes
52. R. Glendenning
53. F. L. Banham

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CONTENTS

HISTORICAL

DOWNES—Fifty Years of Entomology on Vancouver Island - - - - - - 9

GLENDENNING—Reminiscences of Fifty Years of Entomology in the Lower Fraser Valley of British Columbia - - - - - - - - - - - - 16

VENABLES—Fifty Years of Entomology in the Interior of British Columbia - - - 19

GREGSON—The History and Study of External Arthropods affecting Animals and Man in British Columbia - - - - - - - - - - - - 22

MARSHALL—Applied Entomology in the Orchards of British Columbia, 1900-1951 - - 25

HANDFORD—The Dominion Field Crop Insect Laboratory and its Work, Vernon, 1918 - 1938 and Kamloops, 1939 - 1950 - - - - - - - - - - - 31

OLDS—Fifty Years of Plant Quarantine Legislation and Activities in British Columbia - - 34

SYSTEMATIC AND ECONOMIC

SPENCER—The 1951 Status of Our Knowledge of the Insects of British Columbia - - 36

SCHMID AND GUPPY—An Annotated List of *Trichoptera* collected on Southern Vancouver Island - - - - - - - - - - - - - - 41

ROSS—A Preliminary List of the *Trichoptera* of British Columbia - - - - 43

WEINTRAUB—A Preliminary Report on Acaricides tested for Protection against the Tick *Dermacentor andersoni* Stiles on Cattle - - - - - - - - 51

GREGSON—Further Studies on Tick Paralysis - - - - - - - - 54

RICH—A Review of Studies of the Systemic Control of Livestock Insect Parasites - - 58

FOLLWELL—Notes on some *Ptinidae* of British Columbia (Coleoptera) - - - 60

ROSS—The Entomological Society of Canada - - - - - - - - 63

LANE—List of the *Elateridae* of British Columbia - - - - - - - - 65

BANHAM—The Effect of certain Insecticides on the Germination and Growth of Onions. i. Insecticides Applied to the Soil - - - - - - - - - - 67

FINLAYSON—ii. Insecticides applied to the Seed - - - - - - - - 70

HATCH—Observations on the Study of Beetles in British Columbia - - - - 76

MCLEOD—Notes on the Population and Parasitism of the Larch Sawfly, *Pristiphora erichsonii* in British Columbia - - - - - - - - - - - - - 81

WADDELL—Biology and Control of the Cherry Case Bearer, *Coleophora pruniella*, in British Columbia - - - - - - - - - - - - - 85

MORGAN—Effects of Low Winter Temperatures on some Orchard Mites - - 90

WADDELL—A Preliminary Report on the Hemiptera of the Kootenay Valley - - 93

GRAHAM—A Model Problem in Insect Ecology - - - - - - - - 97

ERRATA— Volume 47, 1951 - - - - - - - - - - - - 100

FIFTY YEARS OF ENTOMOLOGY ON VANCOUVER ISLAND

W. DOWNES
Victoria, B.C.

It is to be feared that this account will resolve itself mainly into a history of the work of the Victoria Laboratory. While the entomological events of the past thirty-five years can be related by me from personal observation, those of the previous fifteen can be gleaned only from the published reports of Government departments and those of the Entomological Society of British Columbia.

At the beginning of the century the economic importance of entomology had not attained the prominence in British Columbia that it has today, probably because pests were somewhat fewer and some of the more destructive ones, such as the codling moth, had scarcely arrived. There were no government entomologists in British Columbia and insect outbreaks were dealt with as best they could be by the fruit inspector and district horticulturists. It is evident, however, that growers were not without their troubles for in the report of the Minister of Agriculture for 1902 there were recommendations for control of cutworms, leafhoppers, aphids, red spider, cabbage butterfly, pear and cherry slug, June bug, oyster-shell scale, woolly aphis, tent caterpillars, peach tree borer, onion maggot and raspberry root-borer. In the same year there is reference to a heavy infestation of the oak looper, *Lambdina fiscellaria somniaria*, in the Uplands and Lake Hill districts of Vancouver Island and to an army of caterpillars of *Nymphalis californica* in the Grand Forks district of the mainland, the only insect outbreaks which are mentioned.

The Entomological Society of British Columbia had been founded in 1901 by a few amateur entomologists who were principally interested in collecting Lepidoptera and Coleoptera and the early publications of the Society contain no references to insect outbreaks. The members were principally concerned in collecting and cataloguing the orders in which they were interested. Short lists of Lepidoptera, Coleoptera and Diptera were published in 1906 to 1908 in the Society's "Quarterly Bulletins" and a list of Lepidoptera of British Columbia was compiled by E. M. Anderson of the Provincial Museum, and published by the Society in 1904. A corrected list citing 1061 species was published two year later.

In the early years of the Society the membership was small. Twenty-one members were listed in 1906 and seven years later the number was only twenty-four. Interest gradually waned and no meetings appear to have been held in 1909 and 1910. But in 1911, the late R. C. Treherne was appointed Entomologist-in-Charge by the Dominion Government with headquarters at Agassiz. He immediately set to work to instil new life into the somewhat moribund Society and the result of his efforts was immediately apparent. Treherne possessed a charming, magnetic personality and had the quality of transmitting his enthusiasm to others. The Society appointed him Secretary and he immediately commenced a drive for members, raising the membership from 24 to 101 in a single year. More than that, he succeeded in obtaining from the Provincial Government a grant of $250 a year, on the understanding that papers on economic entomology were to be published in the Society's Proceedings. It was about this time that the centre of the Society's activities settled in Victoria, and for several years the annual meetings were held there. Besides the resuscitation of the Entomological Society the arrival of Reginald Treherne was followed by a burst of activity in the economic field of entomology.

During these years insect pests appear to have been giving agriculturists and horticulturists more trouble

than formerly. Outbreaks of codling moth appeared at Royal Oak, the first of which was said to have been dealt with by the rather drastic method of cutting down the affected trees. The cure does not seem to have been permanent because, in 1914, we find that the Department of Agriculture was engaged in a spraying campaign against codling moth on the Island. This was to have been continued in 1915, but in that year an event occurred which resulted in the permanent establishment of an entomological laboratory on the Island. This was the discovery of pear thrips at Royal Oak. The insect was recognized by Treherne who sent specimens to Ottawa. Gordon Hewitt, Dominion Entomologist, immediately ordered a control campaign to be undertaken against the pest. A. E. Cameron was sent from Ottawa to conduct the investigation and Treherne temporarily closed the Agassiz Laboratory and moved to Royal Oak. A field laboratory was set up in an old barn in the Brydon orchard at Royal Oak and life history studies and spraying experiments were carried out in 1915 and 1916. The result of these was highly satisfactory, the production of the orchard rising from a few hundred boxes at the beginning of the investigation to about 6,000 in 1916. Early in 1917 Cameron returned to Ottawa, Treherne returned to Agassiz, and I was engaged to complete the life history studies of the pear thrips and report upon any other insect troubles which developed.

I should mention here that, in addition to the thrips laboratory, natural control investigations were being carried out by John D. Tothill at Royal Oak. Mr. and Mrs. Tothill remained at Royal Oak for two seasons, during which Tothill was engaged in the study of parasites of tent caterpillars. One of the objects of his visit to British Columbia was to collect puparia of parasites, especially *Blepharipeza*, a tachinid fly, for shipment to eastern Canada. He conceived the idea of introducing the beetle *Calosoma sycophanta* to British Columbia for the purpose of keeping down tent caterpillars and oak loopers. One shipment of these was released in 1917 at Royal Oak by Tothill and another by myself at Victoria a year later. These releases constituted, I believe, the first attempts at natural control by introducing predators in British Columbia. The experiment, however, was not a success as the life history of the beetle did not synchronize with that of either the tent caterpillar or the oak looper and the beetles failed to become established. About this time also, R. Glendenning was engaged in conducting a survey of the currant bud mite situation on Vancouver Island. As the result of his investigations an attempt was made to eradicate the mite and a large number of infested bushes were rooted out.

It was during these years that the strawberry root-weevil came into prominence. During the previous decade the small fruit industry on Vancouver Island had been developing rapidly. The price of fruit was high and the growers, not understanding the habits of the weevil, conducted the culture of strawberries under conditions which gave the pest every opportunity to increase. Such heavy infestations occurred that it was not unusual for newly planted fields to be wiped out in a single season.

The growers apparently were able to obtain little help from the Provincial Government and with the success of the pear thrips investigation in their minds, they petitioned the Dominion Government to send an expert from Ottawa to study the problem of the weevil. Nothing was done until September 1918 when Gordon Hewitt visited Vancouver Island and, together with Treherne and myself, attended a growers meeting at Keating. Feeling appeared to run very high, the growers believing that the government had let them down, and among the more ignorant members of the community there was a feeling of antipathy to government "experts." Treherne, who for some years had studied the weevil on the Mainland, addressed the meeting, outlining the life history and giving the then known

methods of control. He had not been speaking long when a man arose at the back of the hall and shouted—"Yes, you tell us that, but we don't believe a word of it." Hewitt jumped to his feet and said, "We are not here to listen to remarks of that description and we will withdraw immediately from this investigation unless you accept what we tell you as the truth." The meeting quieted down and concluded peaceably. It was arranged that I was to study the strawberry root weevil on the Island as the main project until a method of control that was satisfactory to the growers was worked out.

During the succeeding years experimental work against the strawberry root weevil continued to the exclusion of almost everything else and a great deal of co-operation was received from the growers. Only among a certain ignorant minority the old antipathy to government men persisted. This was evidenced during a meeting which I was addressing at Gordon Head. After I had described the life-history of the strawberry weevil, an old fellow arose and said—"Tell me, professor, can that weevil fly?" I said, "No, it cannot fly, it has no wings." "Now I *know* you're a liar" the old man shouted triumphantly, "because I've seen hundreds of 'em flying all over the place."

In 1919 it was decided to close the Royal Oak field laboratory and the Provincial Department of Agriculture provided us with an office in the Parliament Buildings. This was a cubby hole in one of the turrets, measuring about 6 ft. by 8 ft. and when the entomologist's table, bookcase and chair were installed there was just about room for the entomologist to turn round. However, this was the best they had to offer, and we occupied these palatial quarters for eight years, the only change being to another cubby hole of equal size in another turret. In 1920 I was joined by an assistant, R. Glendenning, and, in addition to strawberry root weevil control, studies of other small fruit insects, Hessian fly and the satin moth were commenced, the latter having just made its appearance on Vancouver Island. In 1921 Glendenning was transferred to Agassiz to take charge of the entomological laboratory and for two years no assistant was appointed for the Victoria laboratory.

During the succeeding five years the control of the strawberry root weevil continued to be the principal project upon which we were engaged at Victoria and strenuous attempts were made to solve the problem by means of weevil-proof barriers. Treherne had already tried this method without success but his tanglefoot barriers were poorly constructed and soon became ineffective. In fact Treherne was pessimistic about the whole project and writing to me in 1919 he says—"I have tried all those suggestions of yours, and if there is anything I have not tried, I would like to know what it is." However, it was decided to give the barrier method another trial and at Gordon Head, I enclosed ten acres of strawberries with a well-made wooden barrier with a tanglefoot band. This was a success in regard to keeping the weevils out, but the tanglefoot band required frequent attention or it soon became ineffective, and, in fact, the whole contraption was unwieldy and a nuisance. A more effective barrier was devised by using heavy lumber with a wide groove ploughed in the upper edge; the groove was filled with crude oil. This needed little attention and provided good protection, but like its predecessor it was clumsy and was soon discarded. The best barrier of all was found to be a wooden barrier with an overlap of tin. This required no attention and was applicable to any situation. Until the invention of the poisoned bait method, these barriers were widely used on Vancouver Island, but were quickly discarded as soon as the more practical method of control by poisoned bait was devised.

When at Royal Oak I had observed that strawberry root weevils seemed to be attracted by partly decayed windfall apples, but an attempt to attract them by means of fresh chopped

apples was a failure. In Seattle, however, J. Forsell, a Washington County Agent, hit upon the idea of using evaporated apples as a bait and this was immediately successful. The poison used was magnesium arsenate, but while this was an effective killer, it became hygroscopic in the presence of the apple and the bait became sticky and unusable. At Victoria we substituted sodium fluosilicate and this proved greatly superior, the bait being not only more attractive but giving a better kill. The comparative trials made at Victoria were published in the Canadian Entomologist.

Forsell had patented his invention and evidently thought he had the strawberry growers over a barrel. He attempted to market his product at an exorbitant price, but was immediately met by substitute baits in Washington and elsewhere. At Victoria we devised a superior bait which did not infringe Forsell's patent. Spoiled raisins were used as the attractant and proved superior to apple. In those days quantities of raisins which had been on the grocers' shelves too long and had become wormy or candied, could be obtained for as little as six cents a pound. (The raisins were gathered up by the raisin company's agents and put through cleaning machines to remove the worms and then were sold in barrels to bakers who used them in raisin bread.) The raisin bait was used exclusively on Vancouver Island but eventually failed through the uncertainty of the supply of raisins, but it was used with great success in New York State against the alfalfa root weevil in 1926.

Other projects about this time included control of the narcissus fly and the two means of control which we experimented with at that time, crude napthalene as a repellent and oil emulsion spray are still the most effective today.

In 1923 Kenneth F. Auden was appointed assistant at the Victoria laboratory. At that time the rose leaf roller, *Cacoecia rosana* was giving much trouble in gardens and orchards and we were devoting some time to the study of its life history and control at a small orchard in the outskirts of Victoria. This minor project was given over to Auden for attention. It seemed to me that my assistant used to return every day with very slight information about the habits of the pest and I wondered why, until I discovered that next door there were two very pretty girls who took an unusual interest in the life history of leaf-rollers and entertained Auden with tea on the lawn every afternoon. When the experiment was transferred to a less attractive location progress was more satisfactory. However, Auden had the making of an excellent entomologist, being a keen observer and a good collector with a capacity for surmising accurately where a species was likely to be found and he seldom returned from a collecting trip without valuable material. He left to go to Northwestern University in 1926 and his death shortly after was very regrettable.

In 1927 John Stanley was appointed assistant at the laboratory. We were then very busy with the European earwig, experimenting with poisoned baits, and as the City of Victoria was conducting baiting campaigns every year in an endeavour to keep the earwig down, we had to survey the city for infested areas. Stanley and I were surveying a district adjacent to Ross Bay cemetery one evening, the method being to examine garden fences with a flashlight, and if a single earwig was found that block was considered infested. Rounding a corner I was suddenly seized by a policeman who wanted to know what I was doing. Explanations followed and the policeman said he had been called to the district by a woman who said she had seen two ghosts, all in white, coming out of the cemetery and one of them had a bright shining eye in the middle of his forehead! That, however, was not the last of it, for on the front page of the COLONIST next morning this appeared in large headlines—"Ghosts coming out of the cemetery resolve themselves into the persons of harmless entomologists."

It was quite a while before we heard the end of that.

John Stanley was an excellent assistant. He later went to Minnesota and afterwards, with Chapman, to Hawaii. He is now a professor at McGill. He was followed in 1928 by Geoffrey Beall. Geoffrey was fond of studying ants and, as at this time the Provincial Department of Agriculture had moved us from the aforesaid cubby hole to a large room in the annex behind the Museum, he was able to have ample room for his pets. He had been told that ants would not cross a barrier of lime so a barrier of slaked lime was built on the floor and a lively colony of ants thrown into the middle. The ants spent most of their time trying to get out and most of Geoffrey's time was spent trying to keep them in. Of course, the inevitable happened. In the night the ants broke down the barrier and wandered off into adjoining offices. In the morning there was serious trouble: the ants were busy climbing up the stenographers' legs and Geoffrey Beall and myself were far from popular. This episode, however, resulted in our being moved to more commodious premises. The authorities decided to segregate us and, as an old dwelling was available at the rear of the Parliament Buildings, we were given three rooms on the upper floor. The rooms were cleaned and renovated and are still occupied by my successor, Harry Andison. Geoffrey Beall later went to the laboratory at Chatham, Ont. He took his doctorate and was in charge of the laboratory for several years. Later he moved to the United States and is now engaged on commercial work.

It will be necessary to pass over the next few years rather quickly. From 1928 to 1933 we were engaged in studying the control of the cherry fruit worm, *Grapholitha packardi*, which was becoming very destructive among sour cherries. Also an endeavour was made to determine if berry blight, *Haplosphaeria deformans*, on logans and raspberries was conveyed by insects. Both these projects entailed extensive field work. A good control for cherry fruit worm was found by spraying for the eggs with summer oil—nicotine spray. No conclusive results were obtained in the berry blight experiments. Other projects included holly leaf miner, earwigs and *Merodon equestris*.

From 1934 to 1939 the chief project at the Laboratory was rearing the earwig parasite, *Digonichaeta setipennis*. Chester Smith came from the Belleville parasite laboratory to get the rearing started on a sound basis and remained with us for three months. Harry Andison was appointed assistant at the Laboratory and J. Aldous a year later.

The rearing and distribution of earwig parasites occupied our attention over the next few years until the end of 1939. The first year the output was 30,020; in 1936, 77,157, and in 1938, 120,056. In the same years we received and distributed hymenopterous parasites of the holly leaf miner, of which two species have become established. In 1936 and 1937 Andison conducted successful experiments against *Scirtothrips longipennis*, a thrips destructive to begonias in greenhouses; experiments were conducted against *Merodon equestris* and some work done in connection with codling moth which again was troubling the growers on the Saanich Peninsula. In 1938, and again in 1939, the cherry fruit fly, *Rhagoletis cingulata*, which had appeared a year or two before, caused serious loss to cherry growers and spraying experiments were conducted against it. This was the first recorded occurrence of this species on Vancouver Island. An attack of cherry fruit fly is said to have occurred many years ago just outside Victoria, in an orchard at Lake Hill which was owned by the late R. M. Palmer, but the species in that case was *Rhagoletis fausta*.

In 1938 a pest new to North America appeared at Victoria. This was *Sitona lineatus*, a small grey weevil destructive to peas and beans. Very good control was obtained by dusting seedling peas with 10 per cent. DDT dust.

About this time, too, we discovered another pest new to North America.

This was the apple sawfly, *Hoplocampa testudinea.* It attacks the young fruit when about an inch or so in diameter, causing it to fall to the ground. Experiments against this pest were conducted in 1940, 1941 and 1942. Excellent control was obtained by spraying with summer oil emulsion and nicotine sulphate just after the petals had fallen. We obtained far better results with this spray than have been obtained in England with nicotine alcaloid.

The year 1940 marks the commencement of far greater expansion of entomological activity on the Island than in former years. In this year the Dominion Division of Entomology decided to establish a Forest Insect Laboratory at Victoria and appointed M. L. Prebble to the position. Prebble remained in Victoria for five years, establishing the laboratory and organizing the work. He then left for Sault St. Marie and was succeeded by H. Richmond who is in charge at the present time. The work of this laboratory extends over the entire Pacific Coast of British Columbia and the Queen Charlotte Islands. Much of the work consists of surveying timber areas, reporting and scouting insect outbreaks, advising operators as to control measures and the study of life histories of forest insects and potential pests. Millions of seedlings also are raised for reforestation. A staff of about 20 is maintained with many more engaged on seasonal work. A sixty-foot motor vessel is used for transporting the men and their equipment to and from areas on the coast where their work is situated. Richmond's offices are in the Post Office Building.

In 1946 Kenneth King arrived in Victoria from Saskatoon to establsh a laboratory for the study of vegetable insects. The establishment of such a laboratory relieves the original Victoria laboratory of a portion of its load, for although nominally a fruit insect laboratory, it has had to handle every kind of insect problem except forest insects. King and his staff are currently engaged in the study of root maggots and wireworms with especial attention to the differentiation of larval forms. A staff of four is maintained, with offices on the second floor of the Belmont Building. Much progress has been made in the study of root maggots and their control. In addition to identifying the larval forms of indigenous species of wireworms, certain introduced species have been identified.

Returning now to the Victoria Laboratory and its work in 1941 and 1942, sufficient earwig parasites had been reared and distributed by that time to establish the species wherever earwings were found in British Columbia. We were then able to turn our attention to a pest which had been troublesome for many years, the June beetle, *Polyphylla perversa.* While formerly it had occurred occasionally and sporadically, sometimes injuring strawberry plantings to a slight extent and sometimes wiping out a quarter of an acre at a time, it now appeared to have established itself as a pest whose annual depredations could be considered inevitable. In fact it had become pest No. 1 to the small fruit grower. In 1943 it was decided to lease a plot of two acres, plant it with strawberries and use it as an experimental ground for June beetle. With the consent of the Department of Agriculture this was done and an agreement entered into with the Saanich Fruitgrowers Association whereby they agreed to supply a certain amount of labour for ploughing and cultivation.

Unfortunately this was a most unfavourable time for starting an enterprise of this sort. These were war years and help of any description was almost impossible to obtain. Andison had been temporarily transferred to Vernon and, with a major project on my hands, I had to manage as best I could. Much of the planting, weeding and cultivation was done by myself with occasional assistance from very unreliable local help and even the stenographer was pressed into service now and then for weeding and hoeing.

But, notwithstanding these difficulties, the plot was kept going somehow and tests were made with certain soil insecticides. An extensive trial was made of a method of using lead arsenate at planting time which was stated to have been very effective against white grubs in the east. But the tough Western June Beetle proved immune to arsenic and was equally scornful of DDT. Other insecticides also gave negative results.

The control of the holly leaf miner which had baffled us for so many years, was solved in 1946 by spraying with DDT just prior to the emergence of the flies in the spring.

Later in 1946 Andison became officer-in-charge of the Victoria laboratory and continued the experiments with soil insecticides against the June Beetle. Experiments were commenced with ethylene dibromide —DD mixture, benzene hexachloride and chlordane. An apparatus was devised at the laboratory whereby liquid insecticides could be dropped in the furrow behind the plough. The experiments were continued through 1947 to 1949. The result of these tests is considered highly satisfactory. Benzine hexachloride at the rate of one pound of gamma isomer per acre gave excellent control of white grubs and there is evidence that it also prevents the females from depositing eggs. Chlordane gave good control of the larvae of the strawberry root weevil. Efforts are now being made to find a soil fumigant that will be effective against the white grub and the strawberry root weevil at the same time and there is some prospect that this will be found.

Other successful investigations carried out during these years were in connection with field control of narcissus fly, western raspberry fruit worm and the leaf hopper *Typhlocyba tenerrima* on logans and raspberries.

Up to the present I have made only slight mention of the systematic side of entomology. In the early days of the Entomological Society many of the members collected extensively on Vancouver Island. The Rev. G. W. Taylor, the founder of the Society, collected Lepidoptera extensively. His collection of Geometridae was purchased by Wm. Barnes of Decatur, Ill., but the balance of his collection was neglected after his death and in time was destroyed by pests. The late G. O. Day and A. W. Hanham were also collectors of Lepidoptera, the collection of the former being particularly fine, every specimen being perfect. He had also a collection of British butterflies and moths representing every known British species. At his death these collections were bequeathed to the Shawnigan Lake Boys' School, where I am told they are neglected and gradually becoming a prey to museum pests. Besides Lepidoptera, Hanham collected Coleoptera and after his death his collection became the property of the Victoria Museum. E. M. Anderson of the Museum staff was a keen lepidopterist and published a list of British Columbia Lepidoptera in 1904. The late E. H. Blackmore accumulated a large and valuable collection of Lepidoptera. At his death most of this was purchased by the University of British Columbia, but some of it was acquired by the United States National Museum. G. A. Hardy of the Victoria Museum is an enthusiastic student of Coleoptera, especially Cerambycidae and he has collected extensively on Vancouver Island.

In 1916 when the pear thrips campaign was under way, the late R. C. Treherne commenced a collection of Thysanoptera, mostly of Vancouver Island species. Treherne published several papers on Thysanoptera in the Society's Proceedings. After his death his collection was transferred to the Canadian National Collection. E. R. Buckell studied the Orthoptera of British Columbia and in 1930 published a list of the Dermaptera and Orthoptera of Vancouver Island in the Society's Proceedings.

The Order Hemiptera seems to have been neglected by our entomologists, though a few collectors like Hanham and J. H. Keen preserved specimens of Hemiptera when they came across

them. It was at the suggestion of R. C. Treherne in 1917 that I commenced a collection of Hemiptera since no one else at that time seemed willing to take up the study of that order. This collection now numbers about 14,000 specimens mostly from Vancouver Island. Nearly all species recorded from British Columbia are represented. Long series, however, cannot be kept for lack of space. About the year 1935 serious collecting had to be abandoned through lack of time to attend to systematic work, but lately has been resumed. A very imperfect list was published by me in 1927 and it is planned to produce a new list in the not too distant future.

Finally, in recent years, Mr. Llewellyn Jones of Cobble Hill created his fine collection of British Columbia Lepidoptera. In respect to the beautiful condition of the specimens Mr. Jones' collection rivals that made years ago by Mr. Day and is much larger. It forms the basis of a new list of British Columbia Macrolepidoptera which is just off the press. We understand that this fine collection will be presented to the University of British Columbia and together with the Blackmore collection the University should possess one of the finest collections of Lepidoptera in the West.

I would like to close this review of 50 years of entomology with a word of appreciation for the co-operation and help that has been received from the Provincial Department of Agriculture. About the time of Treherne's appointment an agreement was made between the Dominion and Provincial Governments that all entomological research in the Province would be conducted by the Dominion Government and the Province would provide laboratory space where no Federal building was available, as at Victoria and Vernon. Over the years, the entomologists at Victoria have had reason to be grateful for this arrangement, for the Provincial Department of Agriculture not only gave office space, but for 27 years provided a stenographer as well. In addition, the services of the Department's mechanics were always available when required and, in short, the Department did all in its power to supplement the meagre facilities of the laboratory. Towards the Entomological Society the Department has always extended a helping hand and it is principally due to this support that the Society has been enabled to print its Proceedings since the Government grant was withdrawn. With such a spirit of co-operation prevailing, the entomologists of British Columbia may look forward with confidence to the future.

REMINISCENCES OF FIFTY YEARS OF ENTOMOLOGY IN THE LOWER FRASER VALLEY OF BRITISH COLUMBIA

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Agassiz, B.C.

These notes make no attempt to be a review of applied entomology; fifty years of such a subject compressed into one paper would be much too long. In addition, excellent accounts of early entomology in this province are available in our Proceedings. The chief of these are G. O. Day's presidential address, and an article by R. C. Treherne, both in No. 4 published in 1914, and a further review by Treherne in No. 13 published in 1921. These give a clear picture of the start of entomology, both systematic and applied up to 1920; they make interesting and profitable reading. So, instead of a tabulation of workers and their problems, I will recount some reminiscences of persons and incidents that may help you to envisage the past. In re-reading the various reviews already published, many memories are revived and personalities re-born, and one realizes the remarkable developments of entomology in the past 50 years—from the limited

but enthusiastic observations and collections of the few early systematists (the Aurelians of British Columbia) to the present highly staffed organization of specialists, watched over by co-ordinators, helped by statisticians, chemists and biometricians, and assisted by researches seconded from other sciences. All this has happened in fifty years.

One thing that strikes with special emphasis in these early records is the dominance of R. C. Treherne in all planned entomology in British Columbia. As you know he resuscitated this Society in 1911, and led all entomological research here until he went to Ottawa in 1924. I knew little of those stalwarts, Harvey, Bush, Dashwood-Jones, Tom Wilson, Sherman and others who lived in Vancouver. They were all, primarily, systematists—with the exception of Tom Wilson, who doubtless, collected on the lower mainland for the most part, as automobile travel was not yet. In Quarterly Bulletin No. 3 is an account of a trip by Harvey and Sherman over the Hope trail to Princeton; it took eight days, and must have been quite a strenuous adventure. Now it can be made in eight hours, there and back.

My first meeting with any of the old brigade was in 1907 when I timidly approached Mr. Thomas Cunningham, then Inspector of Fruit Pests in Vancouver, for employment. I had recently arrived from England complete with letters of reference, but I did not impress him apparently. However, I was soon engaged in applied entomology, as in the following year I was employed in a Vancouver nursery painting "maidens" with coal-oil; a very effective but laborious method of checking woolly aphis. But labour was cheap then—I received 20 cents per hour. My next entomological employment was in 1915 when I first met Mr. Treherne as the result of a chance observation of the presence of the currant bud-mite at Duncan on Vancouver Island. Treherne had greater discernment of talent than Mr. Cunningham, as I was promptly employed by the Provincial Department of Horticulture to survey and eradicate the infestation. I drove around the Cowichan valley in a hired and tired horse and buggy.

Referring again to Mr. Cunningham, I would like to quote part of a paragraph from Treherne's Review of Applied Entomology in No. 4 of our Proceedings, wherein he refers to the general freedom of the province from insect pests. He says:—"If it had not been for the Horticultural Regulations against the introductions of dangerous insect pests, British Columbia entomology up to the present would have been very different. Instead of applying quarantine measures, we would have been studying and controlling insect pests of the farmer far more serious than any we have at present, and the published record of entomology in British Columbia would have been very different." That was in 1914. As you know these Elysian conditions do not now obtain, and on the face of it you might be tempted to think that Mr. Cunningham's successors had been lax in their duties. Such, I assure you is not the case, and the foregoing was quoted only to lead up to the point that I wish to make next—that the large increase in insect pests in this region is due to the greatly changed and changing conditions, not only in agriculture but in every phase of activity. Especially is this change pronounced in the increase in volume and methods of travel, and in the vastly increased acreage and variety of crops grown. I feel sure that many of the injurious species were here for years before they were first recorded as pests, but they had been kept to insignificant and un-noticed numbers through scarcity of food when subsisting on wild hosts ,and by greater vulnerability to parasites and predators under such conditions.

Turning now briefly to two other old timers that I knew well, Anderson and Hanham; Walter Anderson was an Inspector of Indian Orchards; he travelled the whole province on that excuse. The Indians were not

orchardists, but he made many new records, both plant and insect. He was full of Indian lore, and was a good companion as long as you agreed with him. I soon learned to do this; others did not. Mr. Hanham was a bank manager at Duncan on Vancouver Island — a more enthusiastic collector I never knew—unless it is the income tax man or our present president, G. J. Spencer. Not satisfied with a vast collection of beetles and "micros," he also gathered stamps and molluscs, both fresh-water and marine. Even when well on in years he still had the energy and enthusiasm to collect, and I went up both Mount Cheam and Mount McLean with him. I can see him now leaping about on the high rock slides like a young antelope, chasing a small brown butterfly called *vidleri*. On the trip up Cheam Walter Anderson was also along, and Hanham committed the unpardonable sin of disturbing a wasps' nest and of running away so that the wasps were left with Anderson. The tongue lashing he received was equal to the wasps' invective.

Eric Hearle was one of the few specialists in the earlier days; he studied the mosquito problem in the lower Fraser valley for three years under the direction of the National Research Council, and in response to a request for a mosquito control programme by the municipalities on the lower mainland. He covered the valley from New Westminster to Hope by car, boat and airplane. His invaluable report stands like a bridge without approaches, because, when it came to providing funds to implement his recommendations, the municipalities decided that they had no mosquitoes. I went out with Eric Hearle once or twice; his keenness was most marked, and his arms a mass of bumps as he tested the virulence of the bites of the different species. He has gone, along with so many of the noble band of early days—Hewitt, Treherne, Dennys, Seymour Hadwen, Day, Hanham, Sherman, Anderson, Cunningham, Blackmore and Marmont, to mention only those personally known to me.

You will pardon me, I hope, if I become personal again in order to help you visualize the earlier days. I first went to Agassiz in 1919, assisting A. B. Baird who was then studying the natural control of the spruce budworm and tent caterpillars, and in 1921 I took over the Agassiz laboratory when Baird returned to the East. There were few entomologists in the province in those days; Treherne, Buckell, Ruhmann, Venables and Ralph Hopping in the Interior and Downes on Vancouver Island, so that I had the whole of the lower mainland including Vancouver for a field of work. The trend then was for a regional division of work rather than a crop-plant division as is now followed. Speaking medically, most of us were general practitioners rather than surgeons, obstetricians or psychiatrists; and from 1921 until quite recently I delved into every form of insect trouble—from shade tree pests on Vancouver streets to parasite collection and liberation around Lillooet; from grain pests in elevators, and earwigs and slugs in gardens to the wide open spaces where moles and clover seed midges roamed unchecked. I climbed to the tops of tall Douglas fir trees to find what was spoiling the seed-cone harvest, and flew over and waded through mosquito swamps to locate breeding pools. I tried out this and that for flea-beetles, hop aphis, root maggots and fruit flies. Undoubtedly I knew a little about a lot.

The expression—trying out this and that—brings me to my last theme—the ammunition that we had to work with for control measures. All the foregoing was in the pre-DDT era. It was so delightfully simple then. We had so few chemicals to worry about, and unless you drank them neat, they did not poison you. In the provincial bulletin "Diseases and Pests of Cultivated Plants" published in 1924, nine insecticides are listed—lead arsenate, mercury bi-chloride, paris green, hellebore, nicotine sulphate, kerosene emulsion, quassia, whale-oil soap and that great stand-by lime-sulphur. If

none of these proved effective, one had to concentrate on cultural operations, a procedure too often neglected these days. With the evolution of spraying and dusting machinery, and the introduction of dozens of new organic and other chemicals, each more devastating than the last, and with names even more fearful, the humble practitioner finds that he is required to be an engineer and a chemist as well as an entomologist; and in the past few years with the increase in personnel he has to be an accountant, mathematician and administrator in addition. It is all so new and untried with so many different angles to watch.

I have mentioned many workers who have gone to the happy collecting grounds, and should mention one or two of the acquisitions that entomology has made during this period. In 1924 a whirlwind appeared in the province in the person of our president, G. L. Spencer.

His energy and enthusiasm have done much to advance our Society and entomology in general here. From various sources and by devious means he has amassed a vast collection of insects of the province at the University of British Columbia, and his effective tutelage has provided fieldmen with well trained assistants, where before there were none. Finally, mention must be made of the invasion of prairie and eastern entomologists which occurred a few years ago. The outbreak caused no little concern at the time as no control was known, but I am glad to say none has been found necessary. They all turned out to be, not commensals or inquilines, but excellent examples of mutualism, and a perfect symbiosis with the older workers has developed that I am sure will be of benefit to entomology in the province in the coming fifty years.

FIFTY YEARS OF ENTOMOLOGY IN THE INTERIOR OF BRITISH COLUMBIA

E. P. VENABLES
Vernon, B.C.

When I was selected to present a paper dealing with the above subject I felt somewhat at a loss; but, when told that I should be working with Mr. E. R. Buckell, the problem was simplified to a great extent because Buckell and I had already worked together on many occasions. One might approach this subject from various angles, but as I was told that dry statistics were not required I have done my best to avoid them, and to give what may be a somewhat personal narrative dealing with certain characters whom I met and who were, at that time, the sole representatives of our science in the Okanagan Valley. I might deal with my own early struggles in the field of entomology and recount the difficulties which I had to overcome in order to gain a foothold on the ladder, which eventually landed me among the "elite" or, so I should have thought, in 1897.

It was my good fortune to meet the late Dr. James Fletcher quite early in my entomological career, and it was due to his personal interest that I was able to have my material named. Dr Fletcher was an inspiring personality, a naturalist of the old school, who when addressing the public, always stressed the interesting points of insect behaviour, rather than their control, for, as he said, "if one is interested in the subject the artificial control measures are much more easily understood." Fletcher filled the dual roll of Dominion Entomologist and Botanist. I wonder how one of us would feel if landed in that position today. He had one assistant, Mr. Arthur Gibson, who later became Dominion Entomologist and had much

to do with the organization of the Division of Entomology as it exists today.

I remember so well that after sending a number of beetles to Dr. Fletcher for naming, I got a long letter in which he stated that several of the species were of particular interest, and that he would be glad if I could secure more of them because he wished to send them to Professor Wickham in the United States. The receipt of this letter filled me with new enthusiasm and I could understand Darwin's feelings when he got a letter from Lyall, the geologist, dealing with some material Darwin had sent from the Galapagos Islands. Lyall told him that not only were his specimens of great interest, but that his notes were of particular value to science. Darwin, in his reminiscences, says that, on receipt of this letter he sprang over the rocks and made them ring again with the blows of his geological hammer. I wonder if any of the professional workers here today, have, on the receipt of a letter from Ottawa, been inspired to leap on the spray tank and brandish the spray gun with renewed vigour?

It was about 1900 that I was asked by Fletcher to inspect several hundred peach seedlings which had been sent from Ontario to a nurseryman in Vernon. These were suspected of harbouring San Jose scale and I was directed to spray the whole block with kerosene emulsion in case the trees were infested. I believe that this may have been the first time an oil spray had been used commercially in the Okanagan Valley. Of course, in those days, fruit growing was in its infancy and people were very interested in the subject of pests and were rather pleased if they could find something new. They would proudly take their friends to view the work of, perhaps, the red humped caterpillar, or bud worm on their young trees. This would usually be on Sunday afternoon.

The Farmers' Institutes were organized, I think, about 1900 and it was at one of the meetings that I met Dr. Fletcher. The subjects dealt with on some of the programmes were very general, such as, *The Bacon Hog, The Dairy Cow* or *The Blue Jay.* Some of the speakers, however, were never at a loss, and would deal with almost any agricultural subject which the meeting might decide upon on the spur of the moment. For instance, on one occasion a gentleman was on the programme to talk on *The Blue Jay,* but when called upon for his address he said "There are no blue jays in the Vernon district, so I will talk to you on Cheese Factories, which he proceeded to do at some length. In another case, the subject was, Birds in Relation to Agriculture. When he rose to his feet, the speaker, however, changed this to The Construction of Silos.

With regard to the respect due to those who deal with agricultural subjects at farmers' meetings, it may teach some of us proper humility to hear the remarks of a Vernon farmer, who, when my father, who was Institute secretary, asked him to come to one of the meetings, delivered himself as follows: "No, sir. I ain't no use for them lads what talks all night and sleeps all day. Clever know-nothins, what don't know beans when the bag is opened."

One might continue at some length with reminiscences of the very early days, but I must refrain, and deal with the early development of economic entomology. With the arrival of Mr. R. C. Treherne our science took on a more serious, but perhaps, less human tone. Spraying was becoming a somewhat general practice although, even in 1919 and for several years following, hand pumps were the order of the day. Many of us made our own lime-sulphur sprays and this material was applied assiduously in the dormant period, usually before the snow had left the ground, and there was satisfaction in the brilliant yellow colouring of the snow coupled with the penetrating and healthful odour which, one felt, must be toxic to all pests. Of course, around 1900, there were no professional workers, so that

our Society's efforts were quite unaided from that quarter. We circulated manuscript notes with lists of captures and remarks on the season, with occasional mention of injurious insects.

The late Mr. R. V. Harvey was the first secretary of the Entomological Society of British Columbia, a man of tremendous zeal and enthusiasm; he made the trip from Vancouver to Vernon via the Hope-Princeton trail on foot and camped on Long Lake for a fortnight.

Another member, Mr. W. Bush, was an ardent lepidopterist who usually carried a net with a handle about ten feet long with which he would sweep the shade trees in the city park. This, and the white suit which he used to wear, topped off by a large straw hat, attracted much attention, and served to advertise the science of entomology.

Then there was the Rev. G. W. Taylor who specialized in the Geometridae, of which group he had built up a large collection. He was in charge of the Anglican Church in Nanaimo, and it was in that church that I witnessed to what heights an entomologist might rise, or perhaps descend. During his sermon a desirable specimen was hovering round the pulpit light, and Taylor, with a few deft passes of a cyanide bottle captured the insect with no interruption of his discourse.

After Treherne's arrival a new era commenced. "Tre" as he was always called, was a splendid man, full of new ideas, and it was not long before he became secretary of our Society. He added a considerable number of members by insisting that any one he met who was connected with fruit growing, should join the society "for the good of the industry." Mr. Buckell was already engaged in entomological work when I was taken on in 1919. I remember that Tre and I were in Keremeos, and hearing that Buckell was camped up the river, went to look him up only to find that he was away up in the Lillooet country, I believe. His tent was pitched close to the river and a note attached to the flap warned visitors to "look out for the rattlesnake." Buckell's work, dealing as it did with locusts, necessitated quite long trips, which he made on horseback, and in this way covered an area from the Okanagan up into the Cariboo. Later he was provided with a Model T Ford complete with Ruxstel axle, but it would take a volume to recount his adventures with this contraption.

I think that the control of injurious insects has, today, lost the human interest which it had in the early days. Remedies were far more heroic in those days, and could be applied, in most cases, without referring to the chemist, who, today hovers in the foreground and almost excludes the entomologist. Take for instance the recommendations for tarnished plant bug. "Shake them from the trees before sunrise, and destroy them." In the case of the New York weevil remedy — "There seems to be none other than to catch and kill this mischief maker." The red-humped apple caterpillar "should be shaken from the tree and trampled under-foot." The apple-leaf sewer—"The most obvious remedy is, to carefully gather all the fallen leaves with the enclosed larvae and burn them." What has become of those hosts of injurious forms which were present in the late 'eighties? Who among us would recognize the *silky pyrophila*, the *American procris*, the *light-loving anomala*, or the *currant angeroa*, to mention a few. Are they all extinct? We don't see them mentioned on the spray calendar.

The period between 1900 and 1925 was an era in which mechanical barriers and traps were much to the fore. It was not uncommon to see lines of Chinamen, each with a blanket, chasing off swarms of grasshoppers. The strawberry weevil was turned aside with barriers. Crickets were prevented from entering the fields by the erection of wood, tin, or, in some cases, glass fences.

The control of insects now seems to be in the hands of the chemical engineer, and universal destruction is the order of the day. What the

upshot will be remains to be seen and it might be of interest to maintain blocks of orchard trees under the spray programme used in, we will say, 1940 or thereabouts. Some valuable information might be forthcoming affording as it would, a direct comparison on insect populations.

A remark made by the president of the British Horticultural Society a few months ago gives one food for thought. He drew attention to the fact that, most of our leading types of livestock, cattle, horses, sheep, poultry, etc., were produced by the efforts of ordinary farmers, with little, or no assistance from Science as we know it today. He also put forward the idea that Science may, at times, actually delay discoveries by splitting too many hairs.

There is a good deal of truth in these statements, but it will be for the younger men to ponder them.

THE HISTORY OF THE STUDY OF EXTERNAL ARTHROPODS AFFECTING ANIMALS AND MAN IN BRITISH COLUMBIA

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The earliest observations of insects affecting man and animals date back to records made by early explorers on the voracity of some of these pests. In Dr. Cheadle's diary of his trip across British Columbia in 1863 are such comments as "Fearful amount of gadflies. Horses half mad . . . tormented to death by flies. Sandflies and musquitos terribly annoying . . . musquitoes murderous." Remarking on the terrible "musquitoes" at the plains of Sumas, he states that "Indeed men from all countries agree that the musquitoes of B.C. are unmatched for numbers and ferocity."

In the early nineties the mosquito still occurred in millions in the Fraser Valley, rendering work a "purgatory" from early July until September. Relief was obtained when the area was dyked. The first economic studies of animal insect pests were undertaken by Dr. Seymour Hadwen, Animal Pathologist at Agassiz in 1912. From his pen arose publications covering ticks, warble flies and other livestock pests, and under joint authorship with Dr. E. A. Bruce, he published his observations of the migration of warble lavae through the tissues of cattle. In a later bulletin he treated comprehensively the control of insects affecting livestock. In 1919, under the direction of the Dominion Entomologist, Dr. Hewitt, Mr. Eric Hearle commenced his studies of mosquitoes in the Fraser Valley. This was followed by his 1927 publication of the "Mosquitoes of British Columbia."

The study of insect and ticks affecting animals and man was placed on a firm footing with the official establishment of a Dominion Insect Unit at Kamloops in 1928. Eric Hearle was transferred from Indian Head, Saskatchewan, to act as Officer in Charge —and staff. His wire to the Dominion Entomologist, Mr. Arthur Gibson, that he had "located a place that is admirably suited to our needs" referred to an old shack that was located in the centre of town and which had served in its time various purposes from a funeral parlour to a bootlegging joint.

Once established, he set himself, singlehandedly, to the terrific task which lay before him. Not only was he treading on virgin territory as far as his work was concerned, but he was working in a province that contains a richer supply of biological material than all the rest of Canada. This is readily evidenced in later taxonomic studies of various insects.

During the first summer he studied and collected all data and specimens he could lay his hands on. This included mosquitoes, blackflies, sandflies, horseflies, ticks, mites and lice. His

surveys covered the whole of lower British Columbia. Thirteen districts were examined for warbles, which were causing 75 per cent. warble damage in hides. Half a dozen addresses were given during the first month alone. Questionnaires on tick paralysis were sent to all doctors in the Interior and a display was set up at the Vancouver Exhibition. During most of this period he lacked a stenographer.

Within the next two years, mosquito controls had been inaugurated at Kamloops and Kelowna. Tick studies had advanced to include life-history studies of the more important species, including observations of their effect on both domestic and game animals. This brought to light many tick paralysis cases, including an outbreak at Douglas Lake involving 100 head of cattle, out of which 30 were lost. Tularaemia was first recorded for British Columbia in rabbits at Vavenby.

In 1931, the first of a series of large-scale warble control measures were undertaken at Tranquille. From this work it was demonstrated that the grub incidence in cattle could be brought successively from 19 per cent. to 0.3 per cent. within four years. During 1932 and 1933 Hearle spent several months in the vicinity of Jasper Park Lodge making a detailed survey of biting fly conditions. Over 1400 blackflies alone were pinned and determined. Following this work, at the age of 41, his health broke and he was confined to bed. There he continued with the classification of ticks, mosquitoes, blackflies and horseflies, practically completing manuscripts on the ticks and blackflies of British Columbia, before his untimely death in the spring of 1934. His paper "The Ticks of Western Canada" and his bulletin "Insects and Allied Parasites Injurious to Livestock and Poultry in Canada" were published posthumously.

Immediately following Hearle's death, Professor G. J. Spencer took charge of the laboratory during the summer months. On the staff at that time were two assistants, T. K. Moilliet and the writer, and a stenographer. It was during the same year that the original working quarters burned down. While much of the laboratory equipment had been transferred to the Post Office Building, this fire resulted in a loss of field facilities. Steps were taken to secure 32 acres of land three miles west of Kamloops, and a plea issued for the construction on it of a laboratory, wherein the expanding problems of ticks and their diseases could be undertaken with greater safety to the public. It was shortly after Mr. Allen Mail's arrival, in 1937, from Montana, to take over his duties as Officer-in-Charge, that these plans went into effect, and a $21,000 two-storey building was erected. The occupation of the building was followed by the co-operative inclusion of members of the Dominion Rangeland Department and of the Department of Pensions and National Health. The presence of the latter marked the commencement of Western Canadian studies of plague and spotted fever, and surveys of ticks and fleas for their testing were first made by members of the entomological staff. Quarantine quarters and animal housing were added for this disease work, which is still in progress under the supervision of Dr. Humphreys, in what is now the Department of National Health and Welfare.

The next phase of study in livestock insect control appeared with the advent of power spraying, and extensive tests were made to determine the optimum pressures and derris mixtures for warble control under British Columbia conditions. The presence of wartime shortages in addition necessitated comparisons being made with derris and pyrethrum substitutes. Along with these studies came those pertaining to the protection of armed forces from the attacks of biting flies, and in this connection, many tests were made to determine the effectiveness and practical value of mosquito repellents.

In 1943, Mr. Mail resigned his post at this laboratory to accept work in

the United States, leaving as his successor, J. D. Gregson. At this time chemical advances in the production of synthetic insecticides were creating a new aspect in insect control. Before long DDT and thiocyanates replaced pyrethrum fly sprays; citronella and other aromatic oils were cast aside for such superior compounds as 612, dimethyl phthalate and indalone. Gammexane was discovered to be a long-awaited acaricide and mosquito and blackfly oil larvicides were discarded for those embodying DDT. These and other discoveries shed a new light on insect control and, of course, provided much room for new research to meet our conditions. In tick control it has been necessary to discover dosages of BHC that will give maximum protection to cattle and sheep from ticks and keds, yet not prove injurious or objectionable in any way to the host or to its consumer. This has involved numerous field tests each year using artificially infested animals. These experiments have progressed from the deliberate application of overdoses on laboratory animals to cautious recommendation, and finally widely accepted use on range stock. During recent years attention has been devoted to the intriguing study of systemic insecticides, where it has been found possible to rid an animal of its external parasites by a single oral dose of material.

Mosquito control, the administration of which has long passed to the hands of some two dozen communities in British Columbia, has likewise undergone a great transformation, and since the establishment in 1949 at Kamloops of a Household and Medical Unit laboratory, its Officer-in-Charge, Mr. L. C. Curtis, has been engaged in perfecting modern control methods. These include air-spraying and fogging. The latter method is coming into popular use as an adulticide and can be generated by means of a gas engine exhaust adaptation. Since DDT is an effective biting-fly larvicide in such small amounts (one part in 20 million for blackflies), appropriate methods for its release in water are also being studied.

Linked with the economic progress of livestock insect control has been the advance of academic knowledge. Here may be included taxonomic studies, such as have stepped up the known number of British Columbia ticks from 12 to 20 within the past 20 years. The number of flea species known to exist in the province in 1907 was six. During the next 30 years Jordan and Rothchild of the Zoological Museum, Tring, England, described many additional species and by 1936, G. J. Spencer of the University of British Columbia had built this number up to 61. G. P. Holland, now Chief of the Systematic Unit, Ottawa, in his monograph of the fleas of Canada, lists over 90 as now occurring in British Columbia. Spencer's check lists in our proceedings have similarly demonstrated our increased knowledge of pediculous and dipterous parasites.

Ecological observations made at Kamloops have shed much light on tick behaviour, have shown tick life-cycles as long as 21 years, and indicated the gradual increase and decrease of such economic tick species as *Dermacentor andersoni* and *Ixodes pacificus* as apparently affected by civilization. Such outstanding species as the southern spinose ear tick *Otobius megnini* and the relapsing fever carrier, *Ornithodoros hermsi*, have in recent years been taken a number of times during field collections. Particular attention has been paid to the life-history of the warble fly, and by the use of specially constructed girdles on infested cattle, some 400 grubs have been collected for fly studies each spring.

In retrospect, the study of insects and allied parasites affecting man and animals in British Columbia has advanced rapidly and fully. With a staff of twelve now at the Kamloops laboratory, and with the increasing cooperation of Provincial, Dominion and University departments, the future should hold even greater progress.

APPLIED ENTOMOLOGY IN THE ORCHARDS OF BRITISH COLUMBIA, 1900-1951[1]

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Writing in the *Proceedings of the Entomological Society of British Columbia,* Winslow (1913) estimated that in 1912 the total return of the fruit crops of the interior of British Columbia had been $500,000, the actual returns to growers $250,000, and the cost of pest control $53,670. Pest control, therefore. took 20 per cent. of the net returns and that, said Mr. Winslow, was too much.

By 1946 the gross value of the fruit crops had reached about $25,000,000 and the net return may have been about $12,000,000. Cost of pest control had been in the neighbourhood of $1,500,000, or over 12 per cent. of the net returns. Hence the ratio of crop value to cost of pest control remained high, and 34 years later growers throughout the interior fruit-growing areas echoed Mr. Winslow's remark—it was too much. This was particularly so because, despite the drudgery and high cost of pest control, upwards of 10 per cent. of the apple crop was being lost to the codling moth.

Then came DDT and the synthetic organic acaricides. The number of codling moth sprays dropped from 6 or 7 to 4, then to 2 or 3. Cullage from insect infestation became negligible. And because of these new compounds, it became possible to develop the automatic concentrate sprayer, a device, largely British Columbian, that has further reduced the cost of pest control by at least a third and brought to the growers emancipation from one of the most unpleasant jobs in agriculture. Today, pest control is undoubtedly less costly, inconvenient and unpleasant to the fruit growers of British Columbia than at any other time since fruit growing became a sizable industry.

The history of the Entomological Society of British Columbia goes back nearly as far as that of the British Columbia Fruit Growers' Association. Because the affairs of the two organizations have often been closely associated, it is interesting to recall some conditions that were of concern to both and to compare them with conditions in 1951. In the early days of British Columbia fruit culture, Cunningham (1907) wrote as follows: "The standard sprays for the fruit growers may be reduced in number to lime, sulphur and salt for winter, Bordeaux mixture for both winter and summer, and arsenate of lead for summer. With these three sprays the whole line of successful orchard work and destruction of pests and disease may be accomplished." When, in the mid-'40's, the control of orchard pests had become a much more complex problem, the fruit industry no longer relied on Bordeaux mixture and lead arsenate; salt, believed to be an adhesive by Cunningham, had long since been omitted from the lime-sulphur mixture. Dormant-spray materials were high-viscosity dormant oil, distillate oil, dinitrocresol, and lime-sulphur. Summer sprays included the monoethanolamine salt of dinitrocyclohexylphenol, summer oil of medium viscosity and low unsulphonated residue, cryolite, nicotine sulphate, fixed nicotine, micronized phenothiazine, kerosene, rotenone, lime-sulphur, zinc sulphate, elemental sulphur, xanthone, DDT and BHC. Nowadays the trend is to the simple spray schedule, and most growers use heavy dormant oil-lime-sulphur mixture, or heavy dormant oil-dinitrocresol mixture for the early spray and DDT and parathion, or monoethanolamine dinitrocyclohexylphenolate (mono DNP) in summer applications.

There has been a great change in orchard spray machinery since the appearance of Cunningham's spray

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bulletin in 1907. At that time the power sprayer was unknown and the height of mechanization was the hand-operated barrel pump with vertical cylinders. It was superseded by the double-acting horizontal pump. But that did little to relieve the back and arms of the man who supplied the energy. Treherne (1914:67-71) records that the first barrel-type spray pump in British Columbia was purchased by Thomas Cunningham in 1885 for use in the coastal areas. The first of such pumps in the interior of the Province appears to have been in use in Vernon at the Coldstream Ranch in 1895. In 1910 the first gasoline-powered sprayer was imported into the Province; and by 1914 the Provincial government, in the course of its suppressive measures against the codling moth and the San Jose scale, had nine such machines in use. At that time there were, in addition, about 25 privately owned power machines in the Okanagan Valley.

The stationary power sprayers, which reached its greatest development and use in the Wenatchee area of Washington, did not, to any great extent, displace the portable power sprayer in the British Columbia fruit industry. A considerable number of stationary units, however, were installed in the late '30's and early '40's. Portable power sprayers, most of which were eventually operated by tractor power take-offs, did not undergo any basic changes in design until the appearance of the huge "speed sprayer" in the mid-'forties; consequently, they had been made to a fairly fixed pattern for nearly 25 years.

In 1946 a new type of portable sprayer employing an air blast to boost spray fog generated by a hydraulic pump was purchased by the Fruit Insect Laboratory at Summerland. Although this machine proved unsatisfactory, it was, nevertheless, the forerunner of the Okanagan experimental sprayer, a hybrid device built by the joint efforts of the British Columbia and Canada departments of Agriculture and the Defence Research Workshops. It has been described by Marshall (1948). The Okanagan experimental sprayer proved highly successful. It was the forerunner of four commercial models, which, in three years, have virtually revolutionized spraying in the orchards of this province. These automatic concentrate sprayers, as they are locally known, have put the British Columbia fruit industry in an outstanding position in the chemical control of pests. Already the spraying operations of the tree-fruits industry are about 90 per cent. mechanized.

It is a far cry from the laborious and messy business of hand spraying by barrel pump or even by conventional power sprayer to the simple but not unpleasant job of operating an automatic concentrate sprayer. And, fortunately, in addition to having practically eliminated the unpleasantness from spraying operations, the new machine has reduced the cost of labour by about 75 per cent. and the cost of spray materials by perhaps 20 per cent. Capital investment, too, has been greatly reduced. Although the new machines cost about one-third more than their predecessors, they are capable of spraying three times the acreage. Finally, they are operated by one man, the tractor driver, so that they release labour for other important cultural operations at the busiest time of the growing season.

Early in the century, there were few orchard pests in the Province and control of these was based largely on investigations that had been carried out in the United States. Treherne (1914:19-33) recorded the most important insects of the lower mainland: woolly apple aphid, *Eriosoma lanigerum* (Hausm.); green apple aphid, *Aphis pomi* Deg.; rosy apple aphid, *Anuraphis roseus* Baker; black cherry aphid, *Myzus cerasi* (F.); oystershell scale, *Lepidosaphes ulmi* (L.), pear-slug, *Caliroa cerasi* (L); apple leafhopper, *Empoasca maligna* (Walsh); pear leaf blister mite, *Eriophyes pyri* (Pgst.).

The most serious orchard pests of today are orchard mites, which, in the

last five years, have replaced the codling moth in that category. Dash (1914) stated that the mites known to occur in the Okanagan Valley were two species of eriophyds; and the "red spider," *Tetranychus bimaculatus* Harvey; the brown mite, *Bryobia praetiosa* Koch; and the pear leaf blister mite, *Eriophyes pyri* (Pgst.). It is not known when the European red mite, *Metatetranychus ulmi* (Koch), first appeared in the orchards of British Columbia; but in the Okanagan Valley it was common in the 'thirties although not generally troublesome. By 1946 it had displaced the codling moth as the chief orchard pest and it maintains that distinction today. In 1939 the Pacific mite, *Eotetranychus pacificus* (McG.), was discovered at Oliver; it now occurs throughout the Okanagan Valley. Another troublesome orchard mite, the Willamette mite, *Eotetranychus flavus* (Ewing) was recorded at Summerland in 1949 and by the end of the 1950 season it was general throughout the south Okanagan. The brown mite, mentioned by Dash, has persisted, and in 1950 became injurious in a few orchards. The pear leaf blister mite, perhaps the first of the mites to be noticed in the Province, continues to cause trouble sporadically, but only where dormant spraying has not been done for several years. Two other species, the rust mite, *Callyntrotus schlechtendali* Nal., and the silver leaf mite, *Phyllocoptes cornutus* Banks, are also known to occur in the orchards of the interior but, so far, they have not caused measurable loss. In 1950 the two-spotted spider mite, *Tetranychus bimaculatus* Harvey, caused more injury in the orchards than at any other time since it was reported by Dash 36 years before. Still other species of orchard mites are being discovered as an intensive study of the biology of orchard mites gets under way at the Fruit Insect Laboratory at Summerland. Whether there is any connection between the use of DDT and parathion and the rise of the orchard mite problem remains to be seen, but C. V. G. Morgan of the Summerland laboratory has demonstrated a relationship between the use of parathion and the abundance of the most effective predator of orchard mites, the coccinellid beetle, *Stethorus picipes* Csy.

An event of some concern to pear growers of the Province was the discovery of the pear psylla, *Psylla pyricola* Foerst., at Oliver in 1942. Since that time the insect has spread throughout the Okanagan Valley, although it does not yet occur in the Kootenay fruit districts. Parathion has proved to be exceedingly effective against this species.

An unexpected pest, the apple mealybug, *Phenacoccus aceris* Sign., was reported from Nelson in 1927. Previously this insect was known to occur in Canada only in Nova Scotia. Until the introduction of the parasite *Allotropa utilis* Mues., through the Insect Parasite Laboratory, Belleville, Ontario, the mealybug caused some loss of fruit in the Kootenay Valley. The growth of the sooty fungus on fruit coated with the excretion that is copiously shed by these insects rendered the fruit unsaleable.

This year it appears that Okanagan fruit growers may have two additional insects to contend with. A leafhopper, *Erythroneura* sp., has occurred in outbreak numbers on grape at Osoyoos; and the black cherry fruit fly, *Rhagoletis fausta* (O.S.), has been taken in an orchard near Westbank Ferry. These insects may have been present in the Valley for some time.

Treherne (1916) reported the rise of the San Jose scale, *Aspidiotus perniciosus* Comst., as a serious orchard pest, but it was not until some 20 years later that it obtained such a strong foothold in the Oliver, Osoyoos, and Keremeos districts as to be a menace. The pear thrips, *Taeniothrips inconsequens* (Uzel), had been found on Vancouver Island; and the woolly apple aphid, *Eriosoma lanigerum* (Hausm.), which had first been noticed on the lower mainland in 1892, followed the expansion of fruit growing until by 1912 it was general in the interior fruit districts. Later, the relationship between the woolly apple aphid and perennial canker established

the aphid as a major pest in the Okanagan Valley. The eye-spotted bud moth, *Spilonota ocellana* (D. & S.), occurred at Vernon in 1894 but was not common until 1915. Venables (1924) described four leaf rollers attacking fruit trees in the Okanagan Valley; referring to the fruit tree leaf roller, *Archips argyrospila* (Wlkr.), he wrote, "The control of this insect may at present be considered the most serious problem facing orchardists in the interior fruit growing section of the Province"; he recommended for its control the application of 8 per cent. miscible dormant oil. This insect became a minor pest after codling moth spraying with lead arsenate became general. Perhaps its decline may be ascribed to that arsenical.

As mentioned by Hoy (1942), the codling moth has been associated with the British Columbia fruit industry from the early days. Infestations were reported at Victoria in 1900 and at Kaslo in 1905. Referring to the codling moth regulations in force early in the century, the first Provincial fruit pests inspector, T. Cunningham (1907), wrote: "The duty of enforcing these regulations is exceedingly unpleasant, but after all, it is only kindness to the fruit grower to compell him to protect his own interests and those of the country in which it is his good fortune to have his home." Cunningham's words bear out the opinion, still heard, that he was a staunch patriot with a strong sense of duty. Eventually it was found that spraying regulations could not be adequately enforced.

The codling moth did not menace the Okanagan fruit industry until 1916; and, because of vigorous eradication measures undertaken by the Provincial government, the insect was kept in check until 1925. After that, however, control measures were left with the grower, and the codling moth steadily increased in destructiveness until, 20 years later, it almost appeared that it had doomed the apple industry. As mentioned earlier, the situation was immensely improved by the introduction of DDT, an insecticide that appears to be at its best under the climatic conditions of the Okanagan Valley.

Treherne (1921) reviewed the status of applied entomology, noting that in 1915 he was the only professional economic entomologist at work in the Province. Until that time he was stationed at Agassiz and no investigational work had been done in the interior fruit-growing areas. In 1916, however, it appeared that the greatest need for investigations in applied entomology were pending in the Okanagan Valley and, that year, Treherne and M. H. Ruhmann commenced a study of the life-history and habits of the codling moth at Vernon.

In 1917 the Dominion Entomological Branch began to expand its work in the fruit industry of British Columbia by the appointment of W. Downes to work on insects of small fruits at Victoria. After the First World War Treherne was transferred to Ottawa; then, in 1919 and the next few years, E. R. Buckell, E. P. Venables, A. A. Dennys and, still later, A. D. Heriot were successively appointed. All worked from Vernon. Buckell did most of his work on range insects but Venables, Dennys and Heriot worked exclusively on fruit insects. This group of investigators was associated with entomological investigations in the interior of the Province until about 1945. They were a colourful company, and all who were familiar with these Englishmen regret their departure from active work and have a feeling of nostalgia for the old days of the *S.S. Okanagan*, the Model-T Ford, and the collecting trip.

In December, 1938, the Division of Entomology appointed the writer to the Vernon office to work on the control of pests of tree fruits in the Province. During the Second World War the staff at the Vernon office included Venables, Dennys, Heriot, and the writer and, in 1942, Harry Andison, transferred from the Victoria laboratory after the untimely death of Alec Dennys. In 1946, after the south Okanagan had replaced the north Okanagan as the chief tree

fruits area in British Columbia, the equipment of the old Vernon office on the third floor of the Provincial Court House was moved to Summerland. Harry Andison returned to Victoria to follow W. Downes as head of the investigations on insects of small fruits and greenhouses on the coast. Heriot and Venables had retired and were succeeded by C. V. G. Morgan (biology of orchard mites), M. D. Proverbs (insects of stone fruits), D. B. Waddell (spray equipment and chemical formulations), and R. S. Downing (chemical control of orchard mites). In the Fruit Insect Laboratory the naturalist with the modulated English voice had been replaced by the "spray bloke," with the flat Canadian monotone.

In checking back over the years the reader is impressed with the work in the control of fruit insects that has been done by the Provincial Fruit Branch. R. M. Winslow did good service in that field from 1909 to 1917. During the '30's and '40's, W. H. Robertson, then Provincial Horticulturist, now Deputy Minister of Agriculture for British Columbia, saw to it that, when help was needed for pest control, funds were provided as far as possible. The present Provincial Horticulturist, Ben Hoy, conducted eradication work in the early days of the codling moth in the Province and followed that by extensive investigations in the chemical control of a variety of fruit insects, particularly the codling moth, during the '30's and '40's. R. P. Murray, now District supervisor of Horticulture at Kelowna, has been keenly interested in the control of fruit insects and active in that field for 30 years. H. H. Evans, who served as Provincial District Horticulturist at Vernon, also helped a great deal in orchard pest control measures. E. C. Hunt, the Provincial District Horticulturist at Nelson, investigated the control of Kootenay orchard pests and diseases from about 1916 to 1951. From 1937 onward he received help from the investigators of the federal laboratory at Vernon and, later, Summerland. Hunt's work has been of great assistance to the Kootenay fruit grower. At present the Provincial Fruit Branch operates two truck-mounted power sprayers for experimental work in the Okanagan Valley and an automatic concentrate sprayer in the Kootenay Valley.

An interesting feature of pest control investigations in the interests of the tree fruits industry of British Columbia is the close collaboration that has developed between the British Columbia Fruit Growers' Association, the Provincial Fruit Branch, and the Federal Fruit Insect Laboratory at Summerland. The growers' organization keeps in close touch with investigations in pest control and takes an active part in the necessary extension work. The B.C.F.G.A., as it is commonly known, supplied a considerable sum of money for the equipment of the Fruit Insect laboratory at Summerland, which was opened in 1948. On occasion the B.C.F.G.A. has guaranteed growers against loss from field experiments undertaken in their orchards by investigators. The federal entomological and Provincial horticultural services operate practically as one in carrying on field work in pest control for the tree fruits industry. Men and equipment are interchanged so freely that nearly all orchard experiments in applied entomology in this province are joint ones. Seldom in the field of agricultural investigations has this close association between government services been matched; that is a matter of pride for all concerned.

Much of the credit for the present favourable status of applied entomology in the orchards of British Columbia goes to the chemists, whether in the federal service or in industry. The Fruit Insect Laboratory at Summerland is jointly operated by the divisions of Entomology and Chemistry of Science Service, Canada Department of Agriculture, the two organizations being, for practical purposes, so closely integrated at Summerland as to be one. Their work is greatly aided by pesticide research in the chemical industry of the United States, Great Britain, and Canada. In fact,

without that research it is doubtful whether the apple business of this province could have survived. One must recall the ruinous and losing battle that was being waged against the codling moth only a few years ago to realize what the fruit growers owe to DDT, parathion, and the other synthetic organic pesticides in use today.

Although the tree fruits industry has come to place chief reliance on chemical control of orchard pests, it should not be concluded that biological control procedures have been, or are being, overlooked. In 1917, J. D. Tothill and R. C. Treherne of the Dominion Entomological Branch introduced into the Vernon district the mite *Hemisarcoptes malus* (Shimer) to aid in control of the oyster-shell scale, *Lepidosaphes ulmi* (L). That predator, although slow in dissemination, has been doing good work ever since. In 1929, through the Insect Parasite Laboratory, Belleville, Ontario, the parasite *Aphelinus mali* (Hald.) was released in the Okanagan Valley because the woolly apple aphid, *Eriosoma lanigerum* (Hausm.), by reason of its connection with perennial canker of apple, had become a serious orchard pest of the interior fruit belt. Almost from the start *A. mali* was a complete success, and the woolly aphid-perennial canker problem soon subsided. Still later, when the apple mealybug, *Phenacoccus aceris* Sign., became troublesome, through the Parasite Laboratory the parasite *Allotropa utilis* Mues. was released in the infested areas; within five years the apple mealybug caused little concern. From time to time the codling moth parasites *Ascogaster quadridentata* Wesm., *Ephialtes caudatus* (Ratz.) and *Cryptus sexannulatus* Grav. have been released in the interior fruit districts. So far, they do not appear to have exerted any appreciable effect in controlling the codling moth, but *A. quadridentata*, at least, seems to be well established.

It is recognized that compounds such as DDT and parathion may be injurious to parasitic and predacious insects and mites. Consequently, growers are advised to use these insecticides only when their application is clearly necessary. In the meantime, the Fruit Insect Laboratory at Summerland is devoting an increasing amount of time to a study of the effects of spray chemicals on biological control factors. In this work it is assisted by the Biological Control Investigations Unit of the Federal Division of Entomology, which, in 1951, stationed an investigator, D. A. Chant, at the Summerland laboratory.

The increasing complexity of pest control is further illustrated by the attention that is being paid to the effects of spray chemicals upon orchard soils and upon wild life. Experience in various orchard areas in the western United States has shown that serious poisoning of the soil can occur from an excessive concentration of lead arsenate. As the effects of most of today's synthetic organic insecticides in orchard soils are not well known, as investigation on the effects of spray chemicals on soils has been underway at Summerland for the last three years. These studies involve the Science Service divisions of Bacteriology, Chemistry, and Entomology. Effects of spray chemicals on birds and small mammals are being investigated by men representing the Department of Zoology of the University of British Columbia and the Wildlife Service of the Canada Department of Resources and Development. Their summer headquarters are at the Fruit Insect Laboratory, Summerland.

SUMMARY

The first 50 years of the Entomological Society of British Columbia have covered a great expansion in the fruit industry of the Province. Although the membership of the Society has not greatly increased since the early days, the status of its members has changed from predominantly amateur to predominantly professional. So far as control of tree-fruit pests is concerned, there is still a desirable diversification of methods. Chief reliance nowadays is being placed on mechanically efficient control of orchard pests with chemicals, but that

course is not being advocated blindly. Increasing thought is being given to the effects of spray chemicals on the biological balance and on orchard soils in recent years pest control problems have become more involved; and because of their complexity they are, as a rule, being studied not by individuals but by investigator groups that may include entomologists, chemists, horticulturists, zoologists and bacteriologists.

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THE DOMINION FIELD CROP INSECT LABORATORY AND ITS WORK, VERNON, 1918-1938, AND KAMLOOPS, 1939-1950

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ESTABLISHMENT AND STAFF

Comparatively little research work concerning field crop and garden insects had been done in the interior of British Columbia prior to 1918. On April 1 of that year, R. C. Treherne moved his headquarters from Agassiz to Vernon. E. R. Buckell, who had spent four years in the provincial service, was employed by the Dominion Entomological Branch April 22, 1922, and took charge of the Vernon laboratory following Treherne's transfer to Ottawa in that year.*

*The first Government Entomologist appointed in British Columbia was Dr. W. H. Brittain, who held the dual position of Provincial Entomologist and Plant Pathologist from 1912 to 1913 at Vernon. On the appointment of R. C. Treherne, under the Dominion Government in 1912, the entomological work of the Province was divided between them, Brittain taking the interior and Treherne the coast. M. H. Ruhmann was appointed assistant to Brittain in 1912, and after Brittain's departure for Nova Scotia in 1913, he continued in the position of Assistant Provincial Entomologist at Vernon until his death in 1943.—Editor.

The Kamloops laboratory was established on May 1, 1939, with E. R. Buckell in charge, I. J. Ward as Insect Pest Investigator, and G. J. Spencer, University of British Columbia, employed as Entomologist during the summer months. The fruit insect investigations were continued by the staff remaining at Vernon. Buckell retired April 30, 1949, and R. H. Handford was placed in charge. C. L. Neilson was transferred to this staff from Lethbridge in 1947; D. Finlayson and H. R. MacCarthy joined the staff in 1948, and F. L. Banham in 1950.

CONTRIBUTIONS FROM RESEARCH

Grasshoppers. Grasshopper investigations were begun by E. R. Buckell before he joined the Dominion service in 1922 and have been carried on by one or more members of the staff since that date. The main contributions have been as follows:

Grasshopper outbreaks have been charted and described back to 1888; since 1922 these were based on the personal observations of E. R. Buckell and staff. Records of distribution

and notes on ecology, and life history, are available for all known species of Orthoptera in British Columbia. The behaviour patterns of the more important species have also been recorded. While the distribution records were being obtained, series of all the species found in British Columbia were collected and deposited in the laboratory collection. The collection also includes representatives of nearly all other Canadian species. Intensive studies have been made of natural enemies and their effect on grasshopper abundance. The dipterous parasites have received special consideration and annotated lists of the many species have been published. Especially valuable have been the studies involving the relationship between range management and grasshopper abundance. These studies have resulted in much more general attention being paid to the rotation of cattle over grazing areas.

Bait investigations have resulted in a progressive reduction of baiting costs without loss of efficiency. The use of dried apple waste as a carrier with bran, was developed by the Kamloops laboratory. Diesel fuel oil for grasshopper control has been in use many years in British Columbia. More recently the value of chlordane and aldrin sprays has been demonstrated, as well as the more modern methods of application. A motor-driven bait spreader, especially adapted to the rough terrain of British Columbia range lands, was designed and tested by the Kamloops staff, and subsequently came into general use.

A world-famous type of grasshopper control organization, Grasshopper Control Zones, arose from the studies conducted soon after the establishment of the Vernon laboratory. In these zones, control is directed by a committee of ranchers, and the cost of bait materials and of hiring control crews, is collected as part of the land tax on all land within the boundaries of the organized "zone." This is of particular value in that it ensures control operations whenever and wherever needed. The Nicola Grasshopper Control Zone is a widely known, almost classic, example. In that zone, poisoning has been carried on annually for nearly 30 years with the result that no serious outbreak of grasshoppers has occurred there during that time.

Besides the many research contributions made to an understanding of grasshoppers and grasshopper control, assistance has been given the Provincial Department of Agriculture since 1918 with the organizing of control zones and extension work in connection with control.

Crickets. During the severe outbreak of *Anabrus longipes* Caudell in the Okanagan Valley in 1926, officers of the Vernon laboratory introduced, and demonstrated the value of, various types of barriers.

Cutworms. The Kamloops laboratory made observations in 1946 on the value of DDT dusts for cutworm control. At that time a survey of injurious species was begun as a minor project and is still in progress.

Bertha Armyworm. During 1928 the most efficient dilutions of calcium arsenate for controlling young and mature larvae of *Mamestra* (*Barathra*) *configurata* (Walker) were determined experimentally.

Wireworms. Detailed surveys conducted in a few fields in 1930 suggested that grass permitted a greater increase in wireworms than did alfalfa. On December 5 of that year, at Summerland, B.C., wireworms were still relatively close to the surface of the soil indicating that vertical migrations were probably dependent on weather conditions rather than being an inherent part of wireworm behaviour.

Onion Maggot. From studies of life history and behaviour in 1919 and 1920 it was learned that volunteer onions were selected for oviposition in preference to seedling onions. From these observations and experiments based on them it was concluded that "the value of a trap crop in the control of the onion maggot is very

great." At the same time it was learned that off-type, short-necked onions were used very little for oviposition, suggesting possibilities for breeding resistant strains. During that period it was concluded that molasses-sodium arsenite baits were most effective in controlling adults of the species. Experiments during 1950 indicated that lindane surface treatments, aldrin surface treatments, chlordane trench treatments, and DDT seed treatments could be used to replace the more expensive calomel seed or surface treatment.

Cabbage Root Maggot. Extensive experiments in 1919 and 1920 proved that mercury bichloride surface treatments were superior to tarred felt discs.

Colorado Potato Beetle. As a result of the observations and advice of the Field Crop Insect Laboratory, Vernon, an intensive control programme was initiated by the Provincial Department of Agriculture in 1923 in an effort to prevent the spread of the species to other, non-infested districts. Although some spread has occurred since that time, the pest does not occur west of the Similkameen Valley, and in the Okanagan Valley it does not occur north of Penticton.

In addition to experimental work on control, and advice regarding control operations that might restrict the spread of the beetle, the staff of the Vernon laboratory co-operated with the Provincial Government to a considerable extent from 1922 to 1930 in the allocation of insecticides, extension work, and in making a survey of its distribution.

Potato Tuber Flea Beetle. Modifications of R. Glendenning's recommendations for control of the tuber flea beetle have been worked out experimentally, beginning in 1947, for the interior of the province. Differences in life history have also been determined. The 1950 experiments indicated that much time, and possibly considerable expense, could be saved without loss of efficiency by a single application of one of the newer synthetic insecticides to the soil.

Pollinators of Vegetable Seed Crops. During 1918 a study was made of insects observed visiting the flower heads of onion, carrot, beet, mangel, parsnip, and radish, and numerous species were listed.

Pests of Vegetable Seed Crops. A list of insects injurious to vegetable seed crops was prepared from field observations in 1918. Thirty years later the study was resumed. The amount of damage caused by a new pest, *Lygus campestris* (L), was determined experimentally and control methods demonstrated. A study of this pest is being continued and observations have begun on mites and plant lice.

During the years 1943 to 1948 an excellent collection of wild bees, especially leaf-cutter bees and bumblebees, was built up in the laboratory. This now serves as an index to possible pollinators of a wide variety of seed crops.

Collection of insects. An extensive collection of wasps was made during the years 1943 to 1948 and is now available in the laboratory for reference purposes.

During the period 1932 to 1944 dragon-flies were collected intensively and excellent series of all known B.C. species were placed in the laboratory museum.

In the course of work to determine the vector of witches' broom of potatoes an excellent collection of Cicadellidae of the northern Cariboo has been brought together.

Records of Insect Damage. Records of damage by insect pests have been kept since the inception of the field crop insect investigations in the interior of British Columbia 1918.

FIFTY YEARS OF PLANT QUARANTINE LEGISLATION AND ACTIVITIES IN B.C.

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Agriculture means so much to Canada today that any regulatory measures that will provide added protection against foreign pests and diseases are readily complied with by the importing public. But I can remember the time when these import restrictions were not accepted with the same good grace, and a quarantine officer was apt to become as popular as a skunk in a parlor if his middle name was not "Diplomacy." The people of British Columbia should be very grateful to those early quarantine workers who, even at the risk of this unpopularity, had vision enough to establish rules and regulations for this purpose and, as this is a Jubilee meeting commemorating history and progress of our Society in all its various phases, it would seem appropriate that we remember them in these records.

In 1893 the Government of the Province of British Columbia passed what was known as the "Horticultural Board Act." Members of this Board were the Hon. J. H. Turner, Minister of Agriculture; Jas. R. Anderson, Deputy Minister of Agriculture; R. M. Palmer, Thomas Cunningham, and Thomas G. Earle. Many of you will remember some of these men and their sterling qualities.

At a meeting of this Board held December 7 of that year R. M. Palmer was recommended for the position of inspector of fruit pests and, in the following year, he assumed the office and held this position until 1902, when Thomas Cunningham succeeded him. Cunningham was the inspector of fruit pests until March, 1916, when W. H. Lyne assumed charge and was responsible for this work from then until July 31, 1933, at which time all plant quarantine activities then supervised by the Provincial Department of Agriculture were transferred to the Division of Plant Protection, Dominion Department of Agriculture. This, then, is the record of those early appointments. In 1894 rules and regulations made and published under the authority of Section 7 of the Horticultural Board Act constituted the first provision for the inspection and treatment of imported nursery stock and horticultural plant products.

Plant quarantine rules and regulations have undergone many revisions since that time. This was to be expected. The international picture of pest and disease problems is more readily available today. International conferences held over the years have brought about a better understanding of the quarantine regulations and requirements of the various countries with general co-operation resulting.

ACTIVITIES

There has not been much change over the years in the principle of plant quarantines in Canada, but the scope of such activities has naturally been broadened to meet the new problems as they arise. In the early years of plant quarantine work in British Columbia most of the activities were tuned to cover the inspection and certification of imported plants and plant products, but Canada today is an exporting country as well and, naturally, the protection of our foreign trade in horticultural and other agricultural products is just as important as the protection of Canadian agriculture from foreign pests and diseases.

Many of our members are conversant with the work of this Division but, for the benefit of our visitors, the following might be recorded as some of the activities carried out in British Columbia:—

1. *Imports of plants.* I have not the figures of some of the early years covering the amount of imports in this

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connection, but the growth in this trade has expanded with the growth of Canada's population and improved standard of living. This year (1950-51) over 9,000,000 plants were imported into British Columbia. During the examination of this nursery stock some 33,000 plants were intercepted and treated or destroyed on account of pests or diseases.

2. *Inspection of passengers' baggage.* This activity applies mainly to the examination of the baggage of passengers arriving via ship and airliner. It will not be surprising to learn that the greater number of passengers are now travelling via air and that we have lost some of our palatial ships which used to ply between the Orient and Vancouver, as well as "down under."

3. *Introduction of live insects, plant disease organisms, etc.* This is a phase of our work which needs watching very closely, for live insects as a whole are not permitted entry unless for special scientific reasons. Most of this is for investigational and experimental purposes, and it covers not only all stages of insect life, but bacterial and fungus cultures as well. Import permits from this Division are required, and all importations are screened by collaborators.

4. *Imports of plant products.* This type of work is made much easier now due to the fact that by the use of fumigants, we are able to safeguard the country from inroads of certain pests that are found on such imports. We know more of insecticidal gases today, and their effects on various plant products. Stored product inspections and related investigations are carried on by this Division.

5. *Export of plants and plant products.* You will not be interested in figures on export of plants and plant products, but it will be sufficient to say that this work is gradually growing. Canada, as an exporting country, is finding a market in foreign lands and all exports of this type must be certified to comply with regulations of the importing countries. Previous to the war, 209 countries and their protectorates required certification, and it will be interesting for you to know that there were 84 different types of certificates to be made out to meet stipulated requirements of these countries.

6. Bulb certification in British Columbia is a new feature to our general work. The British Columbia Bulb Growers' Federation asked for an inspection service to cover the production of tulips, narcissi, iris, and hyacinths, which service has been provided since 1949.

7. *Ship inspection.* In line with the promotion of Canada's exports, all ships' holds which may be carrying grain or cereal products from Canada are examined prior to loading in accordance with regulations under the Destructive Insect and Pest Act and, if necessary, the ship is treated, either by fumigation or spraying. During the past fiscal year 505 ships were examined in Vancouver and New Westminster, of which 71 were fumigated and 54 sprayed. Canada is the only country in the world which provides a special service of this nature.

8. *Field projects.* Oriental fruit moth survey work has been carried on in the Okanagan Valley during the past several years. There is still no record of an outbreak of Oriental fruit moth in this province.

Inspection of fruit has also been a feature of our work. In the Okanagan the San Jose scale has created a condition whereby certification for export to certain countries might be prohibited. The British Columbia Fruit Growers' Association and the Provincial Department of Agriculture contributed financially to an annual survey supervised by this Division.

Finally, there is our general nursery inspection. This is done as an additional check to locate outbreaks of insects or diseases on our home grown stock. Such inspection, however, does not constitute the only basis of our certification work for the export of

such products. Each consignment is examined when exported, but those early examinations of our nurseries do give us a lead on some of the problems that we might expect.

9. *Seed potato certification.* The only officially recognized seed potatoes in Canada are those duly certified from crops examined by inspectors of the Division of Plant Protection. In British Columbia, which ranks third in production by provinces, the work is carried out under the direction of H. S. MacLeod.

THE 1951 STATUS OF OUR KNOWLEDGE OF THE INSECTS OF BRITISH COLUMBIA

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When putting in a plea several years ago for further collecting to be done in all Orders in this Province, I outlined before this Society, an approximate estimate of the numbers of species recorded up to that time. It seems in order now to take stock again and to record as far as one can, what half a century's collecting has produced in this Province which contains a larger and more varied insect fauna than any other part of Canada.

There are three ways in which fairly correct estimates can be made of the known British Columbian insects:— (1) by searching all published records, (2) by working over the material in the Canadian National collection, where material collected by officers in British Columbia of the Division of Entomology has been sent for many years and (3) by arranging, identifying and listing, collections now existing in this Province.

In the list of references, I have assembled all records of collections, but until an Entomologist is sent from this Province to spend many months going over the National collection and noting all British Columbia records, it will be many years before the lists can be compiled from that source. In the case of even one genus or even one family, one of the systematists at Ottawa might have time to write out the records, but to get these records in all Orders, would be a great task.

The best that I can do at this time, is to go down the list of Orders and to indicate what effort has been put on each one.

THYSANURA. Bristle-tails. Our indigenous fauna has distinctly separated, coastal and dry belt species which do not overlap. In all, I had some seven species which were sent to Dr. Silvestri at Portici, Italy, before the second world war. Correspondence before, during and after the war, failed to get identifications and now that that great man is dead, collections of Thysanura will have to be made all over again and submitted to some other authority.

APTERA. The order is represented by at least one species of native Campodeidae, not uncommon in forest duff and leaf mould in the vicinity of Vancouver and by possibly two species of Japygidae, a dry land form recorded by Saunders from Victoria in 1946 (*Evalljapyx sonoranus* Silv. 1911, previously recorded from Tucson, Ariz.), and another which occurs in rich garden soils around Queen Charlotte City. Mr. R. Guppy recently sent me one specimen from Wellington, Vancouver Island.

The **COLLEMBOLA** are practically untouched and sadly need attention. The only records are of those collected by J. D. Gregson from the Kamloops region and some of my own collecting at the Coast, whose list and identifications of 16 species were published in our Proceedings *44*, 1948.

The **ORTHOPTERA** sens. lat. has been well studied and recorded by Ronald Buckell. There are probably between 110 and 120 species in the Province of which extensive series are placed in the National collection, the Provincial Museum at Victoria and in the Dominion Laboratory in Kamloops. About 80 species are in the University collections. An insect that needs further attention is the readily accessible *Grylloblatta* at Kamloops, discovered by Gregson in 1938 and kept in captivity and partly written up by M. G. Campbell. I feel certain that diligent search in the Interior, of talus slopes similar to those at Kamloops where this insect occurs, will reveal a wide distribution of *C. campodeiformis* in the Province

The **DERMAPTERA** or earwings have been recorded by R. Buckell in his paper "The Dermaptera of Canada," 1929. Of the five species that he has recorded in this Province, only one, *Labia minor* may be indigenous: the rest are immigrants.

The **PLECOPTERA** or Stoneflies of the Cultus Lake region and southwestern British Columbia have been well written up by Ricker, but collections of these insects from further north, especially from cold mountain streams and higher latitudes, are badly needed. With Ricker and Ferris Neave, specialists in this Order, being both stationed at the Biological Station at Departure Bay, identifications can be readily obtained. All material should be preserved in 70% ethyl alcohol, not pinned.

Of the **ISOPTERA** or Termites, only three species have been found in British Columbia, two at the Coast and one in the Interior: on Vancouver Island, all three species occur. They have been written up by Beall and by Spencer in our Proceedings, but the best work on them was done by the late Kenneth Jacob as a huge Master's thesis at the University. Steps are being taken to have at least a portion of this work published.

Of the **CORRODENTIA** less than 20 species have been taken and are now in the University collections. They were named by Miss (Dr.) K. M. Sommerman of the United States National Museum.

The **MALLOPHAGA** or bird lice are represented by a very large collection, part at the Ontario Agricultural College and part at the University. I have published two short lists of species. Steps are being taken to get all the collections named: it will make a pretentious list.

The **ANOPLURA** or sucking lice are represented by about 25 named and several unidentified species at the University. I search almost all the mammals and birds that are taken for the University, but the collections grow slowly; not many species occur that have not already been taken, in both of these Orders of lice.

Of the **ODONATA** of British Columbia, the first list was published by R. C. Osburn in 1905; since then the Order has been well covered by E. M. Walker, F. C. Whitehouse and R. Buckell. Some 78 species have been recorded for the Province. Dr. Walker's material is at the Royal Ontario Museum in Toronto; Mr. Whitehouse divided his collection between the Provincial, Vancouver City and University Museums and the Buckell collection in vials of 95% alcohol, is at the University.

The **THYSANOPTERA** or thrips, were collected only by the late R. C. Treherne, who published two papers on the Aeolothripidae, but did not put out a list of British Columbia species. His collections are in the National collection, Ottawa. As far as I am aware, there are no collections of this Order in the Province beyond about a dozen species at the University.

HEMIPTERA-HOMOPTERA. Of the Hemiptera, H. M. Parshley published a short list in our Proceedings in 1921, but most of the collecting of both sub-orders has been done by W. Downes, whose collection of over 13,000 specimens covering about 800 species, is at his home in Victoria. He has published extensive lists in our Proceedings. Venables has published a list of British Columbia Coccidae. That much more work needs to be done, at least on the Homoptera, is shown by a list of over 100 species taken in the last four years from Quesnel and Soda Creek during a search for vectors of Witches' Broom on potatoes. Dr. B. P. Beirne who named the collection, tells me that four-fifths of the species are not represented in the National collection: this material is all at Ottawa and in the Dominion Laboratory at Kamloops. The Aphids of the Province have been written up by Mr. R. Glendenning and by Alice Macdougall, whose doctorate thesis on the Aphids of British Columbia is at the University of Toronto. In this work she states that about 170 species are recorded from British Columbia. Efforts are being made to have her thesis brought up to date and published. Her collections on over 1100 slides and a large amount of material in alcohol, was donated to the University by her husband, Mr. Patterson, when Alice died.

Of the **NEUROPTERA** sens. lat. I reported 54 species and 10 varieties in our Proceedings of 1942. Our two biggest families are the Chrysopidae and Hemerobiidae. A number of additional species have been collected, but not yet named. The material is all at the University.

Of the **MECOPTERA**, only two species have been named both from the Kootenays, by the late J. W. Cockle. Our Provincial forms are entirely wingless. The minute "Snow Flea" *Boreus*, occurs sparsely on the north shore mountains near Vancouver.

TRICHOPTERA or Caddis flies. Dr. H. H. Ross of Illinois has recorded 142 species from all sources, for this Province. Much of the material upon which his list is named, is at the University and he tells me that at least another 100 species should occur in our borders. Material should be collected in 70% alcohol, not pinned.

Of the **LEPIDOPTERA**, about 1,338 species represented by 9,953 specimens of Macros and Micros, are at the University, purchased from the estate of the late E. H. Blackmore, but many species recorded in Blackmore's check list of 1927, are missing from the collection. A few additional species have been added as they came to hand. The National collection at Ottawa has a large representation from British Columbia collected by Dr. J. McDunnough and the United States National Museum has 2,000 specimens from the Blackmore collection which Mrs. Blackmore gave or sold to Gates Clarke and he later gave them to the Museum when he joined that institution. The Provincial Museum at Victoria has a good display of

Lepidoptera, named to species. Another large collection is that made by Dr. W. R. Buckell, in the Salmon Arm district. This perfectly mounted collection of 773 species (541 Macros and 232 Micros) is in Ronald Buckell's home in Salmon Arm. Mr. J. R. J. Llewellyn Jones of Cobble Hill has recently placed his fine collection of Macro-lepidoptera of 471 species from Vancouver Island, at the University on permanent loan. The most up-to-date check list of the Macro-lepidoptera of British Columbia is that published by Mr. Jones in 1951 in which he records about 1,200 species, with the check list numbers and synonyms brought up to date. A collection of several hundred species of Macros was made some years ago by Mr. W. Downes. Of these, the Geometridee were turned over by him to Mr. Llewellyn Jones. The remainder, consisting of about 400 species from both the Interior and Vancouver Island, is at his home in Victoria.

The **COLEOPTERA.** Until recently the best collection extant of British Columbia species was that of Gordon Stace-Smith of Creston, who has between 2,100 and 2,200 species from this Province. The huge Ralph Hopping collection at Vernon was willed to the California Academy of Sciences and since that institution received also the Hugh Leech collection of water beetles, it now has probably the best representation of British Columbia species. This University has about 2,000 species arranged in 36 Cornell drawers by George Hopping, about three-quarters of them being from this Province. Professor M. Hatch of the University of Washington in Seattle has over 400,000 specimens in his collection, mainly from the Pacific Northwest including material from British Columbia. Since Dr. Hatch has exchanged records with Stace-Smith and has examined all our University material (which includes specimens from Mrs. Hippesley Clarke), his forthcoming book on "The Beetles of the Pacific Northwest" should list fairly well, most of those that have been taken in this Province. Published lists of Coleoptera from British Columbia include those of Reverend J. H. Keen, G. A. Hardy R. H. Harvey, Mrs. Hippesley and Mrs. Clarke (formerly Hippesley). Kenneth Auden's B.A. thesis (unpublished) in the Department of Zoology, consists of a list of about 400 species from the Midday Valley near Merritt, B.C.

The **STREPSIPTERA** remain untouched. Hugh Leech found stylopized bees freely in the arboretum on our campus, but no one has worked on the Order.

The two large Orders, Hymenoptera and Diptera, both strongly represented in the Province, are virtually untouched except for lists of a few families.

HYMENOPTERA. The earliest numbers of our Proceedings contained short lists, but the names are out of date. The University collections have probably the largest number of specimens in the Province, partly separated into Families, most of it unnamed to Species. Outstanding are Buckell's distributional lists of the Ants, Megachilidae, Andrenidae and Bombidae. Buckell and Spencer have listed all the Vespidae that probably occur in British Columbia and Spencer and Wellington the Sphecidae. Many Sawflies and Horntails have been collected and named, but no lists have been published. Foxlee and Guppy have listed some of the Ichneumonidae. Buckell's collections are at Kamloops.

The **DIPTERA** are in much the same condition. After the work and early listings by the founders of our Society, followed by Osburn on Syrphidae, Sherman on Chironomidae, Garrett on several families, Hearle on mosquitoes and Spencer on Tipulidae and Dolichopodidae, little has been published. I have fairly extensive collections of Tabanidae, Syrphidae, Asilidae, Bombyliidae and Tachindae at the University, but only some 40 species of the Tabanidae have been named; many other families have been collected, but are less well represented.

The **SIPHONAPTERA** have been splendidly dealt with in Holland's "Siphonaptera of Canada" in which he lists 89 species for British Columbia. His several papers and two by J. Wagner deal fully with the Order. Brief earlier listings were made by Harvey and Spencer. Holland's book makes the fleas the best worked-up Order in British Columbia, if not in Canada. His huge series is at the National collection and he presented our University with an almost complete set of duplicates in balsam on slides. My collection of about 65 species named by the late Dr. J. Wagner of Belgrade, is also at the University.

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AN ANNOTATED LIST OF TRICHOPTERA COLLECTED ON SOUTHERN VANCOUVER ISLAND

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Although Trichoptera have been the object of considerable study, those of North America are not very well known. Faunistic data, in particular, are often lacking and many described species are unknown except for the type series.

In the hope of contributing a little to the knowledge of these insects we offer the following list of species collected on Southern Vancouver Island, B.C. These specimens were taken, over a period of three years, by the junior author. Where no other indication is given, the specimens were usually taken around the house and grounds, at lights, or by beating foliage. Many, however, were captured near streams or other bodies of water, which were evidently their natural habitat. As some of these places have no names we have adopted the following system of numbering.

(3) Small moderately rapid stream, permanent water, very shaded by bushes, at sea level.

(4) Nearly the same as (3), but often dry in late summer.

(6) Small rapid stream, with still pool, very clear, gravelly bottom, permanent water.

(7) More rapid than (6). Most collecting on this stream was carried out along a stretch running over a shelf of solid rock, with many small "pot holes" created by erosion.

(10) Small shallow muddy pools at about 900 feet elevation, thickly grown with sedges, always dry in summer.

(11) Very small stream falling over steep rock cliff. Water seems to be permanent, though very low in summer.

For other streams along which some collecting was done, we have used the names found on maps of the district.

RHYACOPHILIDAE

Rhyacophila angelita Bks. Fairly common in July. Wellington (4), Nanaimo, Chase R., Englishman R. Falls, Aug. 26, 1950.

R. grandis Bks. Very common, June to Oct. Wellington (3, 4, 7), Nanaimo, Chase R. and Millstone R.

R. norcuta Ross. Common. Forbidden Plateau, Aug., Englishman R. Falls, Aug. 26, 1950. Wellington (7), June and Oct.

R. oreta Ross. Common. Wellington (7), Mt. Benson, Sept. 19, 1950, Englishman R. Falls, Aug. 26, 1950.

R. vaccua Milne. Very common, July to Oct. Wellington (6, 7), Englishman R. Falls, Nanaimo, Chase R, Nanoose Creek, Nanoose Bay, Mt. Benson.

R. vaefes Milne. Wellington (7), June 15, 1950, 2♂♂.

R. verrula Milne. Common. Wellington (6, 7, 11), June and Oct., Englishman R. Falls, Aug. 26, 1950.

R. vuzana Milne. Fairly common, July and Aug. Wellington (4, 11), Nanaimo, Chase R., Englishman R. Falls.

Glossosoma penitum Bks. Wellington (3, 11), June 13, 1950, 2♂♂ and 2♀♀.

Palaeagapetus guppyi Schm. Mt. Benson, Aug. 19, 1949, 1♂.

PHILOPOTAMIDAE

Dolophilodes pallidipes (Bks.). Mt. Cokely (Arrowsmith) Aug. 10, 1948, 1♂. Forbidden Plateau, Aug. 1950, 1♂ and 1♀.

D. dorcus (Ross). Wellington (10), July 27, 1950, 1♂ and 1♀.

Wormaldia gabriella Bks. Very common. Nanaimo, Chase R. and Millstone R., Sept.-Oct. 1950.

PSYCHOMYIIDAE

Polycentropus variegatus Bks. Wellington (4), June 30, 1949 and July 4, 1950, also occasional specimens late July through Sept.

P. flavus Bks. Forbidden Plateau, Aug., 1950, 4♂♂.

P. interruptus Bks. Very common. Wellington, July-Aug.

P. remotus Bks. Forbidden Plateau, Aug. 1950, 2♂♂ and 2♀♀.

LEPTOCERIDAE

Triaenodes baris Ross. Wellington, July 21, 1949, July 27, 1950.

Mystacides alafimbriata H-Gr. Forbidden Plateau, very common, Aug. 1950.

LIMNEPHILIDAE

Colpotaulius secludens Bks. Wellington, Aug. 1, 1948, 1♀.

Grammotaulius betteni Griff. Wellington, occasional in Sept. and early Oct.

Limnephilus externus Hag. Fairly common, Wellington (11), Sept. 28, 1950, and at light mid July through Sept.

L. fuscoradiatus Schm. Forbidden Plateau, Aug., 1950, 1♂ and 1♀.

L. harrimani Bks. Very common, Wellington, Aug.-Sept.

L. insularis Schm. Wellington, Sept. 28, 1948, 1♂; Sept. 23, 1949, 1♂.

L. indivisus Walk. Wellington, June 25, 1948, 1♂; Sept. 10, 1948, 1♂.

L. lopho Ross. Forbidden Plateau, Aug., 1950, 1♂ and 1♀.

L. nogus Ross. Wellington, extremely abundant during Sept. and Oct. Coloration of this species is rather variable.

L. sericeus (Say). Wellington, fairly common in late Sept.

L. sitchensis Kol. Wellington, very common July to Sept. This species also is very variable in coloration.

L. occidentalis Bks. Wellington, rather scarce, Sept.-Nov., one specimen, June 21.

Lenarchus vastus Hag. Wellington, very common Aug. to Oct. Nearly all specimens were taken at light, hence are mostly females. Their breeding haunts were not discovered.

L. rho Milne. Wellington, rather rare, July to Sept. Ten specimens emerged from larvae taken from pool (10).

L. cinnamoneus (Schm.). Wellington, Aug. 12, 1948, 1♂.

Halesochila taylori Bks. Said to be rare, this species was common at Wellington in 1950, coming frequently to light during September and October. A short visit to a muddy lake in October netted about a dozen specimens. Some were bred from larvae taken from this lake, and from the partly caved-in well of the abandoned whaling station at Hammond Bay. The species evidently requires deep, still, permanent water, with abundant aquatic vegetation.

Clistoronia magnifica Bks. Wellington, Sept. 12, 1950, 1♂; Mt. Benson, June 11, 1950, 1♀. The natural habitat appeasr to be mountain lakes. On the Forbidden Plateau the species is very conspicuous during August, large numbers being on the wing each evening at dusk.

Clostoeca disjuncta Bks. Not common, Wellington May 11, 1949 and June 17, 1950; Mt. Benson July 5, 1949, 1♂.

Chyranda centralis Bks. Fairly common, Forbidden Plateau, Aug.

Hesperophylax designatus Walk. Wellington, Sept. 17-20, 1950, 2♀♀. Forbidden Plateau Aug., fairly common.

H. occidentalis Bks. Not common. Wellington, June 15, 1950, 1♂, also from (4) Sept.-Oct., 1948; Mt. Benson, June 11, 1950, 1♀.

Glyphopsyche irrorata Fabr. Fairly common, Wellington, March, April and early May. Goldstream, April 2, 1950, 1♀.

Psychoglypha ulla (Milne). Very common, Wellington Sept.-Oct. and March-April. Reared from (3).

P. bella (Bks.). This species is difficult to collect; it is reluctant to take wing, stays close to its breeding haunts, and never comes to light. Specimens were reared from larvae taken from (6) (emergence date Nov. 9, 1948), and from French Creek (emerged Oct. 17, 1949). Adults were collected at (7) Aug 21, 1949, and Nanoose Creek, Oct. 19, 1949. Larvae were found in still, clear, gravelly pools, when the streams were low in summer.

P. alascensis Bks. Wellington, fairly common in Oct. Two specimens emerged from French Creek, larvae along with the *P. bella* specimen above.

Neophylax rickeri Milne. Common, Wellington, Nanaimo, Chase R., Nanoose Creek, Sept.-Nov.

Ecclisomyia conspersa Bks. Wellington (7), common in May; Forbidden Plateau Aug. 1950, 2♀♀.

Cryptochia pilosa Bks. Wellington (3), June

Apatania sorex Ross. Wellington, June 8, 1950, 1♀.

Dicosmoecus gilvipes (Hag.). Wellington (7) and Millstone R. Oct. 12, 1949, 6♂♂; Nanaimo, Oct. 8-15, 1949, and Sept. 28, 1950.

D. nigrescens Bks. Wellington, Sept. 14, 1950, 1♂ at light, (11) Oct. 13, 1950, 1♀.

D. tristis Bks. Wellington, Millstone R., Englishman R., French Creek, Nanaimo, Chase R., Common, late Aug.-Oct., close to large permanent streams, never taken elsewhere.

LEPIDOSTOMATIDAE

Lepidostoma cascadensis (Milne). Wellington, June 15, 1950, 1♂.

L. hoodi Ross. Wellington, Aug. 24, 1948, 2♂♂.

L. jewetti Ross. Wellington, Aug. and Sept., not rare; Nanaimo, Millstone R., Sept. 28, 1950. Englishman R., Aug. 1, 1950.

L. quercina Ross. Wellington, June 4, 1949, 1♂.

L. roafi (Milne). Very common in Sept., Wellington, Nanaimo, Millstone R.

L. rhino Ross. Wellington, July 10, 1950, 1♂.

L. strophis Ross. Wellington, Sept. 17, 1949, 1♂.

L. unicolor (Bks.). Wellington, fairly common in Aug. and Sept.

A PRELIMINARY LIST OF THE TRICHOPTERA OF BRITISH COLUMBIA

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This list records 142 species of Trichoptera from the Province of British Columbia, but the caddisfly fauna of British Columbia probably contains a good 100 species more. Records to date are chiefly from the southwestern and south-central parts of the Province, and in the main, from lower elevations. Large numbers of species known from neighboring mountains in Washington, Montana, and Alberta, as well as many other species, will undoubtedly be taken in British Columbia with future collecting.

A faunal analysis of the British Columbia caddisflies brings out several interesting points. In southern British Columbia there occurs a curious mixture of two large and distinctive elements, the transcontinental northern fauna and the western montane fauna. In the West the former extends little south of the Canadian boundary. Also emphasized by many species is the distinctive nature of the Cascade fauna in comparison with that of the eastern ranges.

Quite a number of species belong to closely-knit complexes composed of geographically isolated units. Included in this list are *Limnephilus sylviae*, and *Glossosoma wenatchee*. More information on the distribution of these and other species will be of tremendous help in unraveling the story of species genesis on the North American continent.

The largest single set of records comprises the collections made by Dr. W. E. Ricker at Cultus Lake. To Dr. Ricker and many others who have made material available we wish to express our sincere gratitude.

FAMILY RHYACOPHILIDAE

Includes only rapid stream or cascade inhabiting species.

Genus *Rhyacophila* Pictet

R. angelita Banks. July 3 to Nov. 24; Courtenay, Cowichan L. (Cowichan R.), Cultus L., W. of Hope (Silver Cr.). Western, widespread through the montane region.

R. bifila Banks. July 9 to Aug. 10; Cultus L., W. of Hope (Silver Cr.), W. Vancouver (Capilano R.), Vernon, Walhachin. Widespread through the western montane region.

R. coloradensis Banks. Aug. 10 to Oct. 11; Cultus L., W. of Hope (Jones Cr.), W. of Hope (Silver Cr.). Widespread through the western montane region.

R. grandis Banks. June 14 to July 15; Bon Accord, Cultus L., Vancouver (stream on Marine Drive), Vernon. Common in the Cascade and coastal regions from Ore. to B.C.

R. inculta new species.

Male.—Length 12 mm. Head and body various shades of dark brown, antennae and legs paler; wings dark brown with a purplish tinge.

Male genitalia as in fig. 1. Ninth segment nearly cylindrical, with the dorsal area wider than the ventral and bearing a pointed mesal projection extending above and over the base of the tenth tergite. Tenth tergite divided into a pair of thick, blade-like lobes held vertically, without other structures. Claspers with basal segment fairly long, wide at base and narrowed at apex, the ventral margin sinuate; apical segment of moderate size and definitely foot-shaped, the heel rounded and the toe robust. Aedeagus consisting of a mesal tube on each side of which is situated a membranous tubular arm ending in a pad bearing minute setae; these arms are extensile and when stretched out are longer than the claspers.

Female.—Slightly larger than male but similar to it in color and general structure. Eighth segment moderately long and wide, tapering from base to apex, this apical margin somewhat

irregular and without conspicuous features. Spermatheca fairly long and wide, almost entirely membranous but with a few semi-sclerotized areas in its wall.

Holotype.—Male; Cultus Lake, July 23, 1936, H. H. Ross. INHS. *Allotype.*—Female; Cultus Lake, May 18, 1933, W. E. Ricker. INHS. *Paratypes.*—B.C.: Cultus Lake, same data as holotype, 2♂♂; various dates, W. E. Ricker, 25♂♂; 20♀♀; Vancouver, tributary of Lynn Creek, July 20, 1936. H. H. Ross, 1♂, 1♀. OREGON: Big Creek, Clatsop Co., Aug. 31, 1946, S. G. Jewett, Jr., 1♂; Clatskanie, May 9, 1936, K. Gray and J. Schuh, 9♂♂, 7♀♀. Deposited with the holotype and in the collections of the University of British Columbia, Canadian National Collection, and Oregon State College.

This is the species referred to by Ross (1938[1]) and others as *brunnea* Banks. The holotype of *brunnea* is a female from New Mexico and according to our present knowledge of the distribution of this group it is highly likely that it applies to *acropedes* Banks, which might, therefore, ultimately prove to be a synonym of *brunnea.* Rather than make this change, it seems better to await material from the type locality before making a decision as to the exact placement of *brunnea.* The Cascade species which has been recorded under the name *brunnea* is the species here described as *inculta.* It is a sister species of *vao* Milne and *acropedes,* differing from the former in the long projection of the ninth tergite, and from the latter by the more robust, deeper claspers. There is still some uncertainty as to the ultimate distinction between the Cascade species *inculta* and the more eastern *acropedes.* It is noteworthy, however, that *inculta* and *vao* occupy the same range, and are readily separated. Whatever the problem it seems certain that its analysis will be furthered by the retention of the species concept of *inculta.*

1 Ross, H. H. Psyche, 45:1-61, 1938.

R. norcuta Ross. March 13 to 27; Cultus L. Reported from western Calif., Ore., Wash., and B.C.

R. oreta Ross. March 27 to Oct. 12; Cultus L. Previously reported from Utah, Calif. and Ore.

R. perda Ross. July 26; Cultus L. Previously known from western Ore. and Wash.

R. perplana new species

Male.—Length 9.5 mm. Head and body light brown, antennae and legs lighter, the legs nearly straw-color; wings light brown with purplish tinge.

Male genitalia as in fig. 2, in general shape and proportions similar to *angelita* Banks. Tenth tergite forming a curious, angled structure which, when cleared and extended, appears as in fig. 2*a.* The dorsal portion is short and blunt, with a v-shaped apical incision of moderate depth; ventral arm flat. Beneath it articulate the two trianguloid sclerites which are connected with the dorsal tendon of the aedeagus. Claspers with basal segment fairly long and of uniform width, apical segment with a very rounded heel and blunt toe, the toe not extended as a finger-like process. Aedeagus almost exactly as in *angelita,* with the apex of the lateral flap almost lanceolate (it is obovate in *vuzana* Milne).

Holotype.—Male; Cultus L. South Cr., B.C., Nov. 1, 1936, W. E. Ricker, INHS.

This species belongs to the *angelita-vuzana* complex. From the former it differs in the short dorsal lobe of the tenth tergite which is very similar to that of *vuzana;* from *vuzana* it differs in the short apical segment of the clasper, the elongate apical lobe of the aedeagal arms, and the flat ventral arm of the tenth tergite, all of which resemble *angelita.* Since all three species occur at Cultus Lake, it was suspected at first that the specimen of *perplana* might be a hybrid, but examination of the material showed a consistency of characters which suggested that this was a very unlikely possibility. It seems more reasonable, with the information at hand, to consider that the progenitor of the complex was divided to form first the two species, *angelita* and a species very

similar to *perplana*, and that, subsequently, the latter species was again divided to form *perplana*, which remained relatively unchanged, and *vuzana*, which developed additional differences in claspers and aedeagus.

R. tucula Ross. Aug. 25 to Sept 14; Chilliwack L., Cultus L. (along Chilliwack R.), Silver Creek. Recorded from B.C., Ore., Wash., and Wyo.

R. unimaculata Denning. April 16; Robson. Known only from this locality.

R. vaccua Milne. July 19 to Sept 14; Cultus L., Fitzgerald, Keremeos (Shingle Cr. Rd.), N. Vancouver. Widespread through the northern part of the western montane region.

R. vasfos Milne. Aug. 25; Cultus L. Known from B.C. and Ore.

R. vagrita Milne. Aug. 24; Cultus L. Known only from southern B.C.

R. valuma Milne. July 23 to Aug. 25; Cultus L. Known from the Cascade and coastal region.

R. vao Milne. May 20 to Aug. 9; Cultus L., Manning Park (Upper Skagit R.). Known from the Cascade region from Wash. to Alaska.

R. vepulsa Milne. May 22 to Aug. 9; Cultus L., Manning Park (Similkameen R., Allison Pass, 4500 ft.), Stave Falls (Steelhead Cr.). Known from the western ranges from Calif. to B.C.

R. verrula Milne. Aug 12 to 28; Cultus L. Widespread through the western montane region.

R. visor Milne. Aug. 12; Cultus L. Known only from a few localities in the Cascades from Ore. to B.C.

R. vobara Milne. Aug. 12; Cultus L., Revelstoke Mt. Known only from B.C.

R. vocala Milne. July 14 to Aug 16; Cultus L., Fernie, E. of Hope (17 mi. Cr.). Known from the Cascades from Ore. to B.C.

R. vujuna Milne. Aug. 9; E. of Hope (17 mi. Cr.). Known from B.C. and Ore.

R. vuzana Milne. Sept. 9; Cultus L. Known from B.C., Ore. and Calif.

Genus *Anagapetus* Ross

A. bernea Ross. Aug. 9; E. of Hope (17 mi. Cr.). Known from the Cascades in B.C. and Wash.

Genus *Glossosoma* Curtis

G. penitum Banks. June 10 to Aug. 10; Burnaby, E. of Chilliwack (Cheam View), Cowichan L., Cultus L., Peachland, Stave Falls (Steelhead Cr.), N. Vancouver. Occurs chiefly in the Cascades from Ore. to B.C.

G. pyroxum Ross. July 6; Port Coquitlam (Coquitlam R.). Known from B.C. and Ore.

G. velona Ross. April 4 to Nov. 14; Cultus L., N. of Ft. St. James (Middle R., 14 mi. from mouth). Widespread through the western montane region.

G. wenatchee new species.

Male.—Length 9 mm. Color of head and body various shades of light brown, the legs yellow. Mesal process of sixth sternite blunt and round. Genitalia as in fig. 3. Hood large. Lateral plates of tenth tergite sinuate. Cercus elongate, constricted at base and forming a long curve ending in a long. slender, whiplike apical portion surmounted by a thin style; before this style the cercus bears only a few minute setae. Clasper with base greatly constricted, its dorsal margin slightly concave, its ventral margin moderately convex, the apex with a very short, blunt point; the entire clasper is flat and its ventral edge is not angled mesad. Aedeagus tapering to a narrowed apical portion, occasionally with a slight shoulder before the apical constriction but usually more like fig. 4.

Holotype.—Male; Cashmere, Wash., Wenatchee River, June 23, 1940, H. H. and J. A. Ross, INHS. *Paratypes*: WASHINGTON: same data as holotype, 3♂♂; Chiwaukum, Wenatchee River, June 24, 1940, H. H. and J. A. Ross, 1♂. OREGON: Maupin, Deschutes River, June 5, 1947, S. G. Jewett, Jr., 2♂♂. B.C.: Keremeos, Shingle Creek Road, Sept. 14, 1934, A. N. Gartrell, 3♂♂. Paratypes in the collection of the Illinois Natural History Survey, University of British Columbia, and the Canadian National Collection.

This species belongs in the *alascense* complex and is most closely related to *califica* Denning, from which it differs in the fairly broad apex of the clasper, the narrower aedeagus, and the rather low apex of the lateral lobes of the tenth tergite.

FAMILY PHILOPOTAMIDAE

As with the Rhyacophilidae, members of this family occur only in rapid streams or cold brooks.

Genus *Dolophilodes* Ulmer

D. aequalis (Banks). June 26 to Aug. 4; Hope, Keremeos, Princeton. Widespread through the western montane region.

D. dorcus (Ross). Aug. 9-10; Bowser (Cook Cr.), E. of Chilliwack (Cheam View), Cultus L., E. of Hope (11 mi. Cr.). Known only from the western ranges of B.C. to Ore.

D. pallidipes (Banks). July 26; Hedley (Mt. Apex, 6000 ft. el.). Known from B.C., Wash. and Ore.

Genus *Wormaldia* McLachlan

W. anillus (Ross). Jan. 15 to Aug. 10; Agassiz, E. of Chilliwack (Cheam View), Cowichan L., Cultus L., Stave Falls (Steelhead Cr.), N. Vancouver. Known from B.C.

W. gabriella (Banks). June 30 to July 23; Cultus L., Oliver, Sardis, Vancouver. Widespread through the western montane region.

FAMILY PSYCHOMYIIDAE

Most of the British Columbia species in this family are taken along rivers or lakes.

Genus *Neureclipsis* McLachlan

N. bimaculatus (Linnaeus). July 30; N. of Ft. St. James (Middle R. of Takla L.). Holarctic; widespread in the north, eastward to Illinois.

Genus *Polycentropus* Curtis

P. aureolus Banks. Aug. 6; Quesnel. Known previously from the north-central and northeastern parts of the continent.

P. cinereus (Hagen). July 20 to Aug. 2; Cultus L., Keremeos, Quesnel, Seymour, Vancouver, Vernon. Widespread over most of North America.

P. flavus Banks. June 23; Canim Lake. Transcontinental and northern.

P. interruptus (Banks). Aug. 23; Soda Creek. Transcontinental and northern; previously reported from Colo. to the Atlantic.

P. remotus Banks. July 23 to Aug. 23. Peachland. Transcontinental and northern.

P. variegatus Banks. June 14 to Aug.; Burnaby (Stoney Cr.), Cowichan L., Seton L., Vancouver, W. Vancouver (trib. of Capilano R.). Confined to the western montane region.

Genus *Nyctiophylax* Brauer

N. vestitus (Hagen). June 27 to Aug. 19; Bowen Island, Cowichan L., Cultus L., Keremeos, Peachland, Vernon, Victoria. Widespread over most of North America.

FAMILY HYDROPSYCHIDAE

The first two genera inhabit cascades, but the others are primarily river-loving species.

Genus *Arctopsyche* McLachlan

A. grandis (Banks). May 26 to Aug. 16; Cranbrook, Kaslo, Keremeos, Lillooet, Merritt, Seton L., Vancouver. Widespread through the western montane region.

Genus *Parapsyche* Betten

P. almota Ross. May 12; Cultus L. Known from B.C. and Ore.

P. elsis Milne. July 8 to Aug. 9; Cultus L., Jesmond, Lytton (Blue Lake), Manning Park (Similkameen R., Allison Pass, 4500 ft.), Revelstoke. Known from B.C. to Ore.

Genus *Hydropsyche* Pictet

H. amblis Ross. June 11; Mons (Alta L.). Known from B.C. and Ore.

H. californica Banks. Aug.; Cowichan L. Widespread through the western montane region and recorded from Minn.

H. centra Ross. May 27 to June 20; Lillooet (Seton Lake). Known from B.C. and Ore.

H. guttata Pictet.
H. separata Banks, 1936, Psyche, 46:126. *New synonymy.* July 11 to 30; Chilliwack, Kamloops, Rosedale. Holarctic; in North America extending from B.C. to N.Y., northern. Material from North America has been compared with specimens from Switzerland and Russia and found virtually identical with them.

H. occidentalis Banks. June 9 to Aug. 13; Canim L., Cultus L., Lillooet (Seton L.), Nelson, Oliver, Sardis. Widespread through the western montane region.

H. oslari Banks. June 9 to Aug. 27; Chilliwack, Jesmond, Lower Post, Nicola, Oliver, Quesnel, Soda Creek. Widespread through the western montane region.

H. riola Denning. June 23; Canim L. Transcontinental, northern.

Genus *Cheumatopsyche* Wallengren

C. analis (Banks). July 4 to Sept. 11; Agassiz, Nicola, Vancouver (Beaver Cr.). Widespread over most of North America.

C. campyla Ross. June 19 to July 9; Cowichan L., Seton L., Walhachin. Widespread over most of North America.

C. gracilis (Banks). June 28 to Aug. 16; Lower Post, 100 Mile House. Transcontinental, northern.

FAMILY HYDROPTILIDAE

This family comprises the microcaddisflies, most of which are less than 3mm. long, although some reach a length of 6 mm. They occur in a variety of habitats.

Genus *Agraylea* Curtis

A. multipunctata Curtis. July 24 to Aug.; Chilliwack, Cowichan L. Holarctic; widespread across northern North America.

Genus *Ithytrichia* Eaton

I. clavata Morton. July 23; Cultus L., Sardis. Transcontinental, widespread.

Genus *Oxyethira* Eaton

O. serrata Ross. July 31 to Aug.; Cowichan L., N. of Ft. St. James (Middle R. of Takla L.). Transcontinental; previous records from east of the Rockies.

O. sodalis new species.

Male.—Length 2 mm. Color speckled gray, general structure typical for genus. Male genitalia as in Fig. 5. Lateral portion of posterior margin of eighth segment deeply incised just below mid-line; anterior margin of

segment with a wide, fairly deep invagination. From beneath the dorsal margin of the incision on the apical margin there arises a curious process which is very large at the base and narrows rapidly to a curved, long apical portion; this enlarges slightly at apex and gives rise to a single long seta which curves back over the top of the ninth segment. Ninth segment with dorsal portion distinct, its posterior margin crenulate; ventral portion ending in a fairly wide apical plate tapering to a sharp point at apex; segment only moderately invaginated within the eighth. The lateral portion of the ninth bears, on each side, a pair of finger-like processes which diverge at their tips. These two processes are fused at the base and may represent the clasper, which is, otherwise, unaccounted for. Subgenital plate heavy and hook shaped. Aedeagus short, with a spiral process arising near its base and with its apex bulbous; the apex of the spiral process can not be distinguished with certainty in the specimen at hand.

Holotype.—Male; Soda Creek, B.C., Aug. 23, 1950, at light, G. J. Spencer, INHS.

This species is readily distinguished from all others in the genus by the curious lateral appendage of the eighth segment. It does not appear to be closely related to any known species although in shape of aedeagus and general shape of the capsule, it approaches most closely *forcipata* Mosely and *grisea* Betten.

Genus *Orthotrichia* Eaton

O. cristata Morton. July 24; Chilliwack. Transcontinental.

Genus *Hydroptila* Dalman

H. arctia Ross. Aug.; Cowichan L. Widespread through the western montane region.

H. consimilis Morton. Aug. 23 to 27; Soda Creek. Transcontinental, northern.

H. rono Ross. July 6; Port Coquitlam (Coquitlam R.). Widespread through the western montane region.

H. xera Ross. July 6; Port Coquitlam, Coquitlam R. Widespread through the western montane region.

FAMILY PHRYGANEIDAE

With this family begin the typical case-making groups, which contain all the species from here to the end of this list. The Phryganeidae are predominantly marsh inhabitants.

Genus *Agrypnia* Curtis

A. colorata (Hagen). June 13 to 17; Kamloops. Northern, widespread.

A. improba (Hagen). June 11 to July 15; Nicola, Quesnel. Western and northeastern.

Genus *Banksiola* Martynov

B. salina Betten. June 28 to Aug. 18; Kamloops, 100 Mile House. Transcontinental, northern.

Genus *Phryganea* Linnaeus

P. cinerea Walker. June 15 to Aug. 5; Canim L., N. of Ft. St. James (Middle R. at Takla L.), Nicola (Dry Farm), Salmon Arm. Transcontinental, northern.

FAMILY LIMNEPHILIDAE

Genus *Dicosmoecus* Martynov

All three members of this genus are widespread through the western montane region.

D. atripes (Hagen). July 30 to Aug. 31; Brem River, Hat Creek, Indian River, Merritt, Vancouver.

D. gilvipes (Hagen). July to October 15; Arrowhead L., Cultus L., Merritt, Penticton, Quesnel Lake, Vancouver, Wellington.

D. occidentis Banks. Aug. 11 to Oct. 28; Cultus L., Fernie, Quesnel, Wellington.

Genus *Imania* Martynov

I. bifosa Ross. July 20; Glacier. Known from B.C. and Alta.

I. tripunctata (Banks). Wellington. Widespread through the western montane region.

Genus *Cryptochia* Ross

C. pilosa (Banks). Aug. 10; E. of Chilliwack (Cheam View). Known only from the Cascade region in B.C., Wash. and Ore.

Genus *Glyphotaelius* Stephens

G. hostilis Hagen. July 12; Cariboo. Transcontinental, northern.

Genus *Hesperophylax* Banks

Both B. C. species are widespread western forms.

H. incisus Banks. June 6 to Aug. 27; Canim L., Fernie, Hat Creek, Lillooet, Merritt (Midday Val.), Nicola, Penticton, Pavilion L., Upper Peace R. Dist. (between Nelson and Finlay Div., Akie Pass), Wellington.

H. occidentalis (Banks). Aug. 19-20; Gold R.

Genus *Grammotaulius* Kolenati

G. bettoni Griffin. Sept. 12-29; Agassiz; Eburne; Saanich Dist. Known chiefly from the Cascades, from B.C. to Ore.

G. interrogationis (Zeff.). July 2 to Aug. 16; Lower Post, Rolla, Trinity Valley. Transcontinental, northern.

Genus *Philarctus* Martynov

P. quaeris (Milne). July 9 to Aug. 19; Kamloops, Quesnel L. Transcontinental, northern.

Genus *Lenarchus* Martynov

L. fautini Denning. July 17; Barkerville. Known from B.C., N.W.T., and Wyo.

L. rho Milne. June 6 to Sept 28; Agassiz, Bon Accord, Gulf of Georgia, Quesnel, Victoria, Wellington. Known from B.C. and Wash.

L. vastus Hagen. June 10 to Sept. 1; Cowichan L., Departure Bay, Vancouver. Known from Wash. to Alaska.

Genus *Limnephilus* Leach

L. batchewana Denning. July 2-17; Barkerville. Transcontinental, from Western Ont. to B.C.

L. bimaculatus Walker. July 7 to Aug. 14; Kamloops, Kamloops (Lac du Bois), Nicola. Transcontinental, northern.

L. cerus new species

Male.—Length 13 mm. Color of body and appendages various shades of reddish brown, the eyes and leg spines black, the wings finely irrorate with darker brown. General structure typical for genus. Head with one long macrochaeta mesad of the posterior margin of each eye. Front legs with basitarsus subequal in length to succeeding segment. Eighth segment simple, without dorso-apical projection or patch of setae. Genitalia as in fig. 6. Ninth segment moderately thick, reduced to a narrow bridge dorsally. Clasper with proecting portion longer than wide, its apex distinctly truncate, the corners rounded. Cercus of only moderate size, ovate, its mesal face very concave and without sclerotized points. Lobes of tenth tergite with scleortized portion slender, elongate, and curved latero-dorsad at apex. Aedeagus unusually long and slender, the lateral arms with a long slender stalk and a simple, enlarged concave apex bearing a cluster of spines and setae.

Holotype.—Male; Cultus L., B.C. (Sumas Slough), May 11, 1933, W. E. Ricker, INHS. *Paratype.* — Duncan, B.C., September 13, 1919, W. Downes, 1♂. (Canadian National Collection).

This species is most closely related to *lunonus* Ross, differing from it in the shorter cercus which has a convex posterior margin.

L. cinnamoneus (Schmid). Aug. 17; Quesnel, Wellington. Known only from B.C. and Alaska.

L. externus Hagen. June to Sept. 6; Cowichan L. (Cowichan R.), Kamloops, Kamloops (Lac du Bois), Lower Post, Nicola, Summerland. Holarctic, northern.

L. fagus Ross. Sept. 21; Cultus L. Cascades, from Ore. to B.C.

L. flavastellus Banks. Sept. 23; Wellington. Cascades, B.C. to Alaska.

L. harrimani Banks. July 15-20. Bon Accord, Vancouver (Stanley Park, Stream No. 1), N. Vancouver (Grouse Mt., 4000 ft.), W. Vancouver (Capilano R.). Western, from Ore. to Alaska.

L. hyalinus Hagen. June 28 to Sept. 28; Nicola, 100 Mile House, Quesnel, Shuswap, N. of Ft. St. James (Tachla R. at Stuart L.), Vernon. Transcontinental, northern.

L. indivisus Walker. July to Sept. 25; Chilcotin, Mission, Midday Val., Nicola, Soda Creek. Transcontinental, northern.

L. insularis Schmid. July 17 to Sept 28; Barkerville, Wellington. Known only from B.C.

L. lopho Ross. Aug.; Barkerville, Hedley, Hope Mts. (6000 ft.), Revelstoke (6000 ft.). Known from B.C. and Ore.

L. nogus Ross. Feb. to Oct. 15; Arvas, Chilliwack, Cultus L., Departure Bay, Eburne, Haney, Point Grey, Vancouver, New West'r. Cascades, from Ore. to B.C.

L. occidentalis Banks. May 4 to Sept. 13; Duncan, Kamloops, Vancouver Island. Widespread in the western montane region.

L. pacificus Banks. Feb. 19 to Oct. 31; Cowichan L., Departure Bay, Hatzic Prairie, Wellington. Chiefly in the Cascades, from Ore. to B.C.

L. secludens Banks. June 28 to Aug. 27; Aspen Grove, Chilcotin, Fernie, Jesmond, Kamloops, Lower Post, Merritt (Midday Val.), Nicola, 100 Mile House, Penticton, Rolla, Soda Creek. Transcontinental, northern.

L. sericeus (Say). July 17 to Oct. 14; Australian, Barkerville, Chilcotin, Hat Creek, Kamloops, Quesnel, Shuswap Narrows, Soda Creek. Transcontinental, northern.

L. sylviae Denning. May 31; Vancouver (Seymour Mt., 4700 ft.). Known from B.C. and Ore.

L. tarsalis (Banks). July 18 to Aug. 2; Kamloops, Quesnel. Transcontinental, northern.

Genus *Chyranda* Ross

C. centralis (Banks). Aug. 9-26; Fernie, Tahumming. Widespread through the western montane region.

Genus *Clostoeca* Banks

C. disjuncta (Banks). May 3 to June; Bon Accord, Vancouver. Widespread through the western montane region.

Genus *Halesochila* Banks

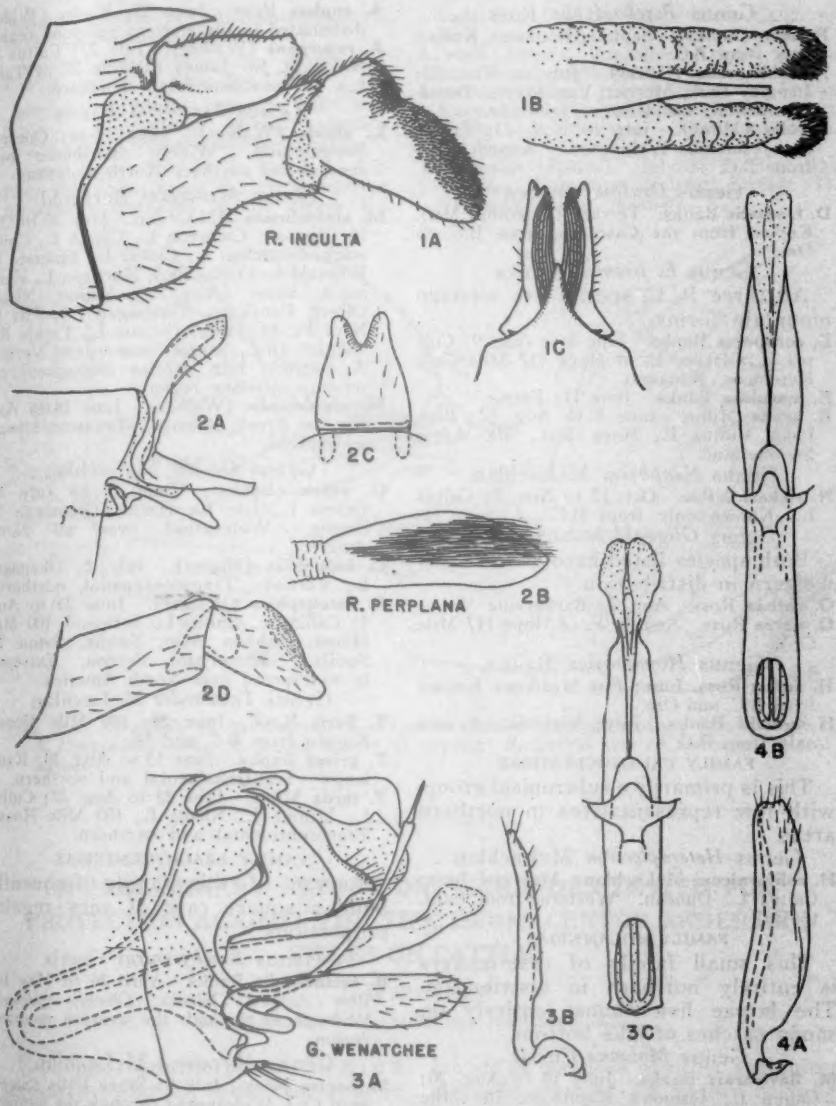
H. taylori Banks. Oct. 12; Point Grey, U.B.C., Wellington. Known only from B.C.

Genus *Hydatophylax* Wallengren

H. hespera Banks. July 3 to Aug. 1; Nanaimo (Departure Bay), N. Vancouver (Mosquito Cr.). Known from B.C., Wash., and Calif.

Genus *Glyphopsyche* Banks

G. irrorata (Fabricius). Wellington. Transcontinental, northern.



Figs. 1-4. Genitalia of caddisflies. 1, *Rhyacophila inculta*: *A*, lateral aspect; *B*, aedeagus, dorsal aspect; *C*, tenth tergite, dorsal aspect. 2, *Rhyacophila perplana*: *A*, tenth tergite, lateral aspect; *B*, apex of lateral arm of aedeagus, lateral aspect; *C*, tenth tergite, dorsal aspect; *D*, clasper. 3, *Glossosoma wenatchee*: *A*, genitalia, lateral aspect; *B*, clasper, ventral aspect; *C*, Aedeagus, ventral aspect. 4, *Glossosoma alascense*: *A*, clasper, ventral aspect; *B*, aedeagus, ventral aspect.

Genus *Psychoglypha* Ross

P. bella (Banks). Sept. 3; Nanaimo. Known only from B.C.

P. subborealis (Banks). July to Nov. 23; Langley Park, Merritt, Vancouver. Transcontinental and western montane.

P. ulla (Milne). July to Nov. 23; Cultus L., Jesmond, Wellington. Known only from B.C.

Genus *Drusinus* Betten

D. frontalis Banks. Terrace (Thornhill Mt.). Known from the Cascades, from B.C. to Ore.

Genus *Ecclisomyia* Banks

All three B. C. species are western mountain forms.

E. conspersa Banks. June 4 to Aug. 9; Cultus L., Glacier, E. of Hope (17 Mile Cr.), Keremeos, Nanaimo.

E. maculosa Banks. June 11; Fernie.

E. scylla Milne. June 8 to Aug. 12; Blue Lake, Cultus L., Hope Mts., Mt. Apex, Summerland.

Genus *Neophylax* McLachlan

N. rickeri Milne. Oct. 12 to Nov. 7; Cultus L. Known only from B.C.

Genus *Oligophlebodes* Ulmer

Both species listed here are entirely western in distribution.

O. ruthae Ross. Aug. 2; Barkerville.

O. sierra Ross. Aug. 9; E. of Hope (17 Mile Cr.).

Genus *Homophylax* Banks

H. andax Ross. June; Pitt Meadows. Known from B.C. and Ore.

H. crotchi Banks. July; Victoria. Known only from B.C.

FAMILY CALAMOCERATIDAE

This is primarily a subtropical group, with few representatives in northern areas.

Genus *Heteroplectron* McLachlan

H. californicum McLachlan. May and June; Cultus L., Duncan. Western, from Calif. to B.C.

FAMILY MOLANNIDAE

This small family of case-makers is entirely northern in distribution. The larvae live almost entirely on sandy patches of lake bottom.

Genus *Molanna* Curtis

M. flavicornis Banks. June 10 to Aug. 20; Canim L., Jesmond, Kamloops, 100 Mile House, Quesnel, N. of Ft. St. James (Tachla R. at Stuart L.). Transcontinental, northern.

FAMILY LEPTOCERIDAE

This widespread family includes both stream species and lake species.

Genus *Athripsodes* Billberg

A. cancellatus (Betten). June 23 to Aug. 17; Canim L., Cultus L., Lower Post, 100 Mile House, Seton L., Summerland. Widely distributed over central and northern North America.

A. cephus Ross. June 25; Kaslo. Widely distributed in the western montane region.

A. resurgens (Walker). July 23; Cultus L., N. of Ft. St. James (Middle R. at Takla L.). Transcontinental, northern.

Genus *Leptocella* Banks

L. albida (Walker). June 14-16; Quesnel, Summerland. Widely distributed over central and northern North America.

Genus *Mystacides* Berthold

M. alafimbriata Hill-Griffin. May 30 to Oct. 16; Agassiz, Cameron L., Canim L., Chilliwack, Cowichan L., Cultus L., Emerald L., Emerald L. (Yoho Pk.), Harrison L., Keremeos, Mons (Alta L.), Nelson, Nicola, Oliver, Penticton (Okanagan L.), Pitt L., N of Ft. St. James (Stuart L., Tachla R.), Saanich Dist., Sardis, Summerland, Vernon. A common lake species throughout the western montane region.

M. sepulchralis (Walker). June 14 to Aug. 20; Hat Creek, Quesnel. Transcontinental, widespread.

Genus *Oecetis* McLachlan

O. avara (Banks). June 27 to July 25; Cultus L., Lac La Hache, Okanagan L., Sardis. Widespread over all North America.

O. immobilis (Hagen). July 2; Okanagan L., Vernon. Transcontinental, northern.

O. inconspicua (Walker). June 23 to Aug. 1; Canim L., Cultus L., Jesmond, 100 Mile House, Salmon Arm, Sardis, Seton L., Squilax, Summerland, Vernon. Extremely widespread over North America.

Genus *Triaenodes* McLachlan

T. baris Ross. June 28; 100 Mile House. Known from B.C. and Ill.

T. grisea Banks. June 13 to Aug. 30; Kamloops. Transcontinental and northern.

T. tarda Milne. June 23 to Aug. 27; Cultus L., Minnie L., Nicola L., 100 Mile House. Transcontinental and northern.

FAMILY BRACHYCENTRIDAE

Larvae of this family frequently build a square case of very regular proportions.

Genus *Brachycentrus* Curtis

B. occidentalis Banks. April 26 to May 14; Bon Accord, Nicola, Oliver, Quesnel. Widespread through the western montane region.

Genus *Micrasema* McLachlan

M. bactro Ross. July 6; Stave Falls (Steelhead Cr.). Widespread through the western montane region.

FAMILY LEPIDOSTOMATIDAE

Members of this family build either log-cabin cases or slender, cylindrical ones.

Genus *Lepidostoma* Rambur

L. cascadensis (Milne). May 28 to July 15; Cultus L., N. Vancouver (Mosquito Cr.), W. Vancouver (Capilano R.), N. of Whonnock (Whonnock Cr.). Widespread through the western montane region.

L. hoodi Ross. June 10; Nanaimo (Departure Bay). Known from B.C. and Ore.

L. jewetti Ross. Sept. 25; Wellington. Known from B.C., Ore. and Calif.

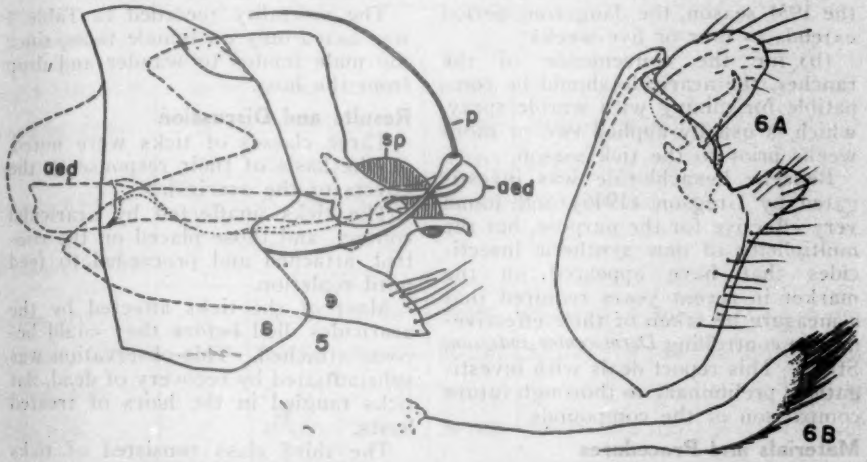
L. pluvialis (Milne). June 28; 100 Mile House. Widespread through eastern ranges of the western montane region.

L. rayneri Ross. July 16-18; Cultus L., Lillooet, Rosedale (Fraser R.), N. Vancouver. Apparently restricted to the Sierra Nevada and Cascade range from Calif. to B.C.

L. roafi (Milne). Vancouver, Vernon, Transcontinental, northern.

L. strophis Ross. June 5 to Oct. 16; Cultus Lake, N. of Ft. St. James (Middle R. at Takla L.), Vernon. Transcontinental, northern.

L. unicolor (Banks). July 15 to Sept. 13; Duncan, Vancouver (along Stream I). Transcontinental, northern.



Figs. 5-6. Genitalia of caddisflies. 5, *Oxyethira sodalis*: genital capsule, lateral aspect. 6, *Limnephilus cerus*: *A*, lateral aspect of capsule; *B*, lateral arm of aedeagus, lateral aspect.

A PRELIMINARY REPORT ON ACARICIDES TESTED FOR PROTECTION AGAINST THE TICK DERMACENTOR ANDERSONI STILES ON CATTLE[1]

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Economic considerations, which necessarily play an important role in the acceptance and use of any recommended insecticide, are particularly critical factors in the schedule of ranchers, whose products do not give them as high a return on their investments of property, care, and, notably, labour as do those of other agriculturists. In view of the nature of range practices in the British Columbia interior, a spray, if it is to be accepted by the ranchers, should be such that it might be applied only once: when the cattle are concentrated near spray chutes before being dispersed over the spring and summer grazing grounds. To advocate a compound of low residual properties for use against ticks will necessitate the rounding up of

1 Contribution No. 2921, Division of Entomology, Science Service, Department of Agriculture, Ottawa, Canada; presented at the 50th Anniversary Meetings of the Entomological Society of British Columbia in Vancouver, June 13-18, 1951.
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scattered cattle for a second treatment and result in the ultimate breakdown of the control program.

The dangerous portion of the tick season generally lasts but two or three weeks. However, two factors contribute to the need for a chemical that can remain toxic for longer periods:

(a) in an occasional year, such as the 1951 season, the dangerous period extends to four or five weeks;

(b) for the convenience of the rancher, the acaricide should be compatible for mixing with warble spray, which is usually applied two or more weeks prior to the tick season.

Benzene hexachloride was investigated by Gregson (1946) and found very effective for the purpose, but the multiplicity of new synthetic insecticides that have appeared on the market in recent years required that a measure be taken of their effectiveness in controlling *Dermacentor andersoni* Stiles. This report deals with investigations preliminary to thorough future comparison of the compounds.

Materials and Procedures

The following materials were used:

Wettable powders: C-854 (p-chlorophenyl p-chlorobenzenesulphonate), Neotran (bis(p-chlorophenoxy) methane), chlordane, and gamma isomer of BHC.

Emulsions: aldrin, dieldrin, chlordane, and gamma isomer of BHC. The emulsifier employed in the formulations was Atlox 1045.

A concentration of 0.5 per cent. of active ingredient was chosen primarily on the basis that it was well within the effective limits for control of the tick by BHC (Gregson, 1946). This chemical, therefore, was used as a basis of comparison for the others before devoting time for a more complete examination of their properties.

The number of cattle which could be maintained on the laboratory premises was limited; hence one litre of a formulation was applied to the head, neck, and shoulders of each of four yearling steers and four heifers. One other steer was untreated and served as a control.

Ticks were collected at approximately weekly intervals and placed on the hosts' backs. The attached ticks were counted and removed at the end of each feeding period, before a new batch was placed on each animal. Occasional checks showed that the feeding ticks were not completing their development and leaving the host before they could be counted.

The mortality recorded in Table I was based only on female ticks, since the male tended to wander and drop from the host.

Results and Discussion

Three classes of ticks were noted, on the basis of their response to the effects of the acaricides:

The ticks unaffected by acaricidal contact, and those placed on the control, attached and proceeded to feed until repletion.

Most of the ticks affected by the acaricides died before they could become attached. This observation was substantiated by recovery of dead, flat ticks tangled in the hairs of treated hosts.

The third class consisted of ticks which attached on treated cattle but which died before becoming replete. Their bodies were collected, still attached by their mouth parts, where they had been feeding.

The variable reactions of the ticks to acaricides suggested a variable resistance of the individuals to the chemicals, even among those ticks which succumbed. Unfortunately, at the levels of acaricide concentrations used, the proportions of ticks of the third class were so low that a quantitive comparison of the types was not justified. However, in this preliminary study the totals of dead ticks were of primary concern; consequently, the last two classes were added and the sum was used to provide the data for the mortalities recorded in Table I.

Table I indicates that Neotran and dieldrin can be ruled out for future tests. Neotran had been tested on *D. albipictus* (Pack.) (unpublished data) as a dust at one, three, and five per cent. concentrations, and found ineffective in controlling that species.

TABLE I.

MORTALITIES OF *DERMACENTOR ANDERSONI* FEMALES EXPOSED TO VARIOUS ACARICIDES SPRAYED ON CATTLE

Chemical	Numbers of Female Ticks Placed on each Host Animal and Percentage Mortalities‡ (in parentheses) after Six to Nine Days							
	Number of Days After Treatment							
	5	12	21	27	33	41	50	57
Emulsions								
gamma BHC, 0.5%	50	25 (86)	25 (80)	25 (86)	25 (67)	25 (67)	0 (67)	-
chlordane, 0.8%†	50	25(100)	25(100)	25(100)	25(100)	0 (96)	-	-
aldrin, 0.5%	50	25(100)	25(100)	25 (71)	25 (33)	0 (70)	-	-
dieldrin, 0.5%	50	25 (0)	25 (0)	0 (0)	Discontinued			-
Wettable Powders								
gamma BHC, 0.5%	25	25(100)	25(100)	25(100)	9 (67)	0 (0)	10 (-)	0 (0)
chlordane, 0.5%	25	25(100)	25(100)	25(100)	22 (67)	0 (40)	10 (-)	0 (0)
Neotran, 0.5%	25	25 (2)	25 (5)	25 (-)	16 (3)	0 (0)	10 (-)	0 (0)
C-854, 0.5%	25	25 (82)	25 (85)	25 (90)	19 (40)	0 (23)	10 (-)	0 (0)

‡ Corrected by Abbot's formula (Shepard, 1946 p. 33) so that the controls show zero percentage mortality.

† Chlordane emulsion contained 0.8% of active ingredient because of an error in formulation.

Aldrin and C-854 showed some promise. The former compound produced greater mortalities than the comparable strength of BHC for 21 days, but its effects diminished considerably during the subsequent period. C-854 produced consistently lower mortalities than the corresponding BHC formulation. However, the mortalities of 82, 85, and 90 per cent. obtained during the first three weeks may be sufficient for practical control of infestations in the field.

The wettable form of BHC appeared to be more effective than the emulsion. A similar comparison could not be made for chlordane because the emulsion form contained 0.8 per cent. as opposed to 0.5 per cent. of the wettable powder. BHC and chlordane wettable powders produced identical results for three days, after which chlordane emulsion killed all of the ticks for 33 days and 96 per cent. until 44 days. A performance of this type might very well answer the needs of ranchers even in the occasional years of extraordinarily prolonged tick activity.

Although there were no records of toxic effects among the cattle treated, the problem of danger to livestock is an apt one and deserves mention. At the present time published data are not available for effects of dermal doses of aldrin, dieldrin, Neotran, and C-854 when applied to cattle.

Bushland *et al* (1948) and Radeleff and Bushland (1950) have investigated chlordane and benzene hexachloride in this respect. Bushland and his coworkers reported that a wettable powder at 0.25 per cent of gamma benzene hexachloride caused no injury

when applied once as a drenching spray to three cows. However, when similarly applied at 0.75 and 1.5 per cent. of gamma isomer, benzene hexachloride did affect and kill the cows. Two Hereford heifers, thoroughly sprayed in eight treatments at four-day intervals with 1.5 per cent. chlordane emulsion, were not affected.

In the same paper the authors reported that of ten cattle sprayed with a two per cent. suspension of chlordane at two-week intervals, three cows died after 10-12 days following the fourth spraying. Other cattle sprayed similarly with two per cent. of benzene hexachloride (12 per cent. gamma isomer) showed no apparent injury.

Radeleff and Bushland (1950) found that suckling calves were particularly susceptible to benzene hexachloride, toxaphene, and chlordane at various levels from 8.0 per cent. to 0.025 per cent. of the toxic ingredients. In this experiment the calves were sprayed until thoroughly wet.

The meagre published results of work on this phase of the toxicity of the newer insecticides emphasizes a need for further investigation. To aggravate the situation, no standardized method of applying the insecticides has been attempted, for each group of workers has a different set of problems. For example, in the present experiment only one litre of insecticide was sprayed on each of the cattle, whereas Radeleff and Bushland and Bushland *et al* wet their cattle thoroughly. Each group was guided by the limits of its purpose in performing one experiment.

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FURTHER STUDIES ON TICK PARALYSIS[1]

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Tick paralysis in British Columbia and adjacent territories, as in South Africa and Australia, has long remained a disease of baffling origin. Though it is generally conceded that the symptoms produced in the host are brought on by the injection of a toxin by the tick, the reason why ticks of the same species vary in potency is still a puzzle. The solution to this mystery has been complicated by a series of factors which have included such nebulous conditions as are involved in different host and tick species, host susceptibility, and host immunity. Zumpt (1950) even questions whether these factors are the only ones, and as he suggests, the physiological condition of the individual tick seems to be of considerable significance, a factor which has resulted in studies too frequently containing so many unknowns that no logical pattern is apparent. This, together with the shortness of the annual period of natural tick activity, has rendered progress in the etiology of the disease slow. Nevertheless, each year some advance has been made and considerable data gained toward the understanding of this interesting phenomenon.

In British Columbia tick paralysis is caused by the female of the Rocky

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Mountain wood tick, *Dermacentor andersoni* Stiles, and is mainly a disease of cattle. If these animals are pastured on tick-inhabited ranges during the active adult tick season of March and April, they become infested with large numbers of the parasites. These congregate in dense masses on the heads and shoulders of the victims and attach for their seven-to-ten-day blood meal. It is toward the end of this period, when they have become replete with blood, that they may paralyse their host. Sheep, dogs, and humans are also affected, but usually on these hosts there are few ticks or only one.

This species of tick mates while feeding, which, as shown by Gregson (1944), enables the female to engorge to repletion much more rapidly than when deprived of a male. The feeding period of a mated female is approximately seven days, after which it drops from its hosts, whereas an unmated tick remains attached, half-engorged, for several weeks. For some time it was thought that fast-feeding, mated females were more virulent than the slow-feeding, unmated ones. This view is, however, weakened by the facts that in human paralysis the male tick is rarely present and that in most instances the causative tick is only half-replete at the onset of paralysis.

TEST ON SUITABILITY OF HOSTS

During the past few springs further attempts have been made at the Kamloops laboratory to demonstrate the conditions responsible for the production of paralysis. Since so many factors appear to be involved in the occurrence of paralysis in tick-infested animals, one of the first steps was to find a host that is subject always to paralysis. To permit large-scale infestations involving animals on which ticks had not previously fed, small laboratory animals were sought. It was with some degree of surprise that white mice were discovered to be ideal hosts of the adult ticks, for never in nature has this stage of tick been taken from the numerous wild mice present in tick-infested areas known at the Kamloops laboratory. Though the ticks in the laboratory had to be protected from the actions of their hosts by large rubber discs placed around the animals' necks, the cleanly nature of mice does not prevent other species of ticks in nature from attaching and engorging. The successful application of this discovery was short-lived, for it was found that though rapidly engorging, mated ticks did kill the mice, death was apparently due to a severe anaemia, as shown by blood counts, and slow-feeding ticks produced no typical symptoms of paralysis. These results covered 37 infestations. Of 18 mice infested with mating ticks, ten died and eight grew only sluggish by the time the ticks became replete. Nineteen, infested with single female ticks, were unharmed, and at the end of the seven days (the normal period for paralysis to appear) bore half-engorged specimens. One mouse harboured five and another two females for the same period without apparent ill effects, though a third with four females died — presumably because of the large blood meals of the ticks.

Mice, then, apparently do not fill the need for a host susceptible to paralysis —unless, of course, the ticks used in this experiment were for some reason not capable of producing paralysis.

Rabbits and guinea pigs appear to be immune to tick paralysis, as is suggested by the lack of symptoms of this disease during the course of infesting these hosts with thousands of ticks in spotted fever studies at the Rocky Mountain Laboratory, Hamilton, Montana (W. L. Jellison, personal communication), and during smaller-scale infestations at Kamloops. Dogs are relatively susceptible to tick paralysis and would undoubtably form convenient test animals were it not for the difficulties of procuring and maintaining them in sufficient numbers. Infestations on each of six puppies caused a paralysis in three of the hosts, on which one, four, and two ticks had attached.

TESTS ON LAMBS

In 1951, 30 lambs were available for further adult tick feeding observations at Kamloops. Though previous experiments had shown that all tick-infested lambs do not necessarily become paralysed, at least some are paralysed under favourable conditions.

METHODS AND DATA OF INFESTATIONS

The ticks in these experiments on lambs were confined on the hosts by dome-shaped screen capsules, which were anchored to the surrounding wool by linen threads. To provide optimum conditions for the ticks, each capsule was placed over a clipped area that had been washed free from natural grease. A dampened pad of absorbent cotton served to maintain the humidity until the ticks had attached. Unless these precautions were taken a large number of the ticks died before attaching. Such mortalities were excluded from the studies, the results of which are tabulated below.

Summary of infestations of individual lambs, various feeding rates, and paralysing powers of engorging females (Complete data of this experiment are available from the author):

1. Infested April 4, 13, 27 with 5, 4, 2♀ and 5, 0, 2♂ respectively. Three* females fed rapidly. No paralysis.
2. Infested April 26 with one pair. Female fed rapidly without producing paralysis.
3. Infested March 28, 31, April 7 with 5, 1, 0♀ and 0, 0, 20♂ resp. None fed rapidly. No paralysis.
4. Infested April 16, 26, May 8 with 6. 1, 8 ♀ and 0, 1, 8♂ resp. Seven females fed rapidly. No paralysis.
5. Infested April 13, 13, May 3 with 4, 0, 6♀ and 0, 4, 10♂ resp. Two females fed rapidly. No paralysis.
6. Infested April 13, 13, 13, 25 with 6, 0, 1, 1♀ and 0, 12, 1, 1♂ resp. Two females fed rapidly. No paralysis.
7. Infested April 11, May 3 with 1, 1, ♀ and 2, 3♂ resp. Both females fed rapidly. No paralysis.
8. Infested April 14 with 10♀ and 0♂. None fed rapidly. No paralysis.
9. Infested April 16, 28, May 8 with 3, 2, 8♀ and 0, 1. 8 ♂ resp. The two females of the second group paralysed the lamb moderately when only half-replete. Recovery followed their removal. Five females of the last group fed rapidly, causing no further paralysis.
10. Infested April 14, 30 with 6, 1♀ and 3, 1♀ resp. Of the first group, one female fed rapidly, causing a slight paralysis which disappeared upon its release. Two subsequent females fed rapidly, causing no paralysis.
11. Infested April 14 with 3♀ and 0♂. None fed rapidly. No paralysis.
13. Infested March 28, 31, April 13, 30, May 10 with 5, 1, 5, 2, 10♀ and 5, 1, 0, 1. 0♂ resp. One female of the first group fed rapidly causing a slight paralysis. Four slow, and a subsequent fast feeder produced no symptoms. The lamb finally was paralysed severely by five slow-feeding ticks of the third group. Paralysis remained as the ticks were taken off at hourly intervals until the last was off. Two fast-feeding females of the fourth group and ten slow feeders of the last produced no further paralysis.
14. Infested April 11, 27 with 1, 1♀ and 2, 1♂ resp. Both females fed rapidly, the first producing a slight paralysis, the second none.
17. Infested May 3 with 3♀ and 2♂. Two females fed rapidly. No paralysis.
18. Infested April 12, 28, May 8 with 1, 1, 7♀ and 2, 2, 8♂ resp. First two females fed rapidly, causing no paralysis. Seven females of the last group fed rapidly, producing severe paralysis.
19. Infested April 30, May 8 with 2, 8♀ and 2, 8♂ resp. All females fed rapidly, each group producing a slight paralysis.
20. Infested April 25 with 2 pairs. Both females fed rapidly. No paralysis.

* Failure of all females paired with males to feed rapidly is probably due to a delay in mating.

21. Infested April 13 with 1 pair. Female fed rapidly. No paralysis.

SUSCEPTIBILITY OF THE LAMBS

The lambs used in these experiments were as uniform a group as practical inasmuch as they were much of an age and none had been exposed to ticks before. Some of the lambs that were unaffected by ticks during the first infestations were susceptible to paralysis later (lambs 9 and 18). It is, however, unlikely that this later response was due to sensitization since six others (lambs 1, 3, 4, 5, 6, and 7) did not become paralysed after repeated infestations during similar periods. Indifference to tick paralysis because of development of host immunity can probably be ignored also, since paralysis was produced twice within eight days in two lambs (13 and 19). These facts suggest that some factor in the tick, rather than in the lambs, was responsible for the paralysis in the above instances. Though this assumption is later moderated by indications of a host resistance, it does offer a theory that is valuable for further progress, in view of the scantiness of substantial evidence.

VIRULENCE OF THE TICK

If, then, the presence of paralysis is considered to be due to a condition within the tick, attention can be directed toward a comparison of the virulence of the sexes. Though males are frequently associated with females in paralysis cases, at the Kamloops laboratory there is no record of paralysis caused by males themselves. In the experiments under discussion 32 male ticks were fed on lambs without apparent symptoms of paralysis. Presumably the sparsely feeding male tick can be omitted as a direct causative agent in this disease. Indirectly, it was felt it might constitute a factor by increasing the feeding rate of the female.

Assuming, now, that paralysis is caused only by the female tick, an analysis can be made of the effects of mated and unmated ticks on the host to determine whether or not the feeding rate is related to the virulence of the tick. In 28 separate infestations involving 80 pairs of ticks (fed in single pairs or in series up to ten pairs on 16 lambs) 50 ticks mated and engorged rapidly enough to drop replete in seven days. Of these 50, only 11 were possibly involved in the production of the six cases of paralysis that resulted. It is possible that actually only one tick was involved in each case, so that the ratio of virulent mated ticks to benign ones might then be approximately one to eight.

In ten other infestations involving 52 females without males (fed in numbers from one to ten on eight lambs), paralysis occurred in one lamb (13) on which five ticks were feeding. The possibility that all these ticks were involved in the production of the paralysis cannot be dismissed, since the symptoms did not subside until the last tick was removed. If, however, only this last tick was implicated, the ratio of virulent unmated ticks to benign ones was one to fifty-two. The above data suggests that mated, rapidly feeding female ticks are more likely to cause paralysis in lambs than slower-feeding ones.

As judged from this laboratory's records, the fact that slow-feeding, solitary females are so virulent in human infestations, where a tick seldom engorges without causing paralysis, suggests that man is more susceptible to the action of the tick than lambs—a theory that agrees with the mentioned variation in susceptibility among different species of animals. Lambs, then, are moderately resistant, since, out of the eight cases of paralysis mentioned, only two were severe enough to produce a loss in the use of the limbs; the remaining lambs exhibited only an unsteady gait. In contradiction to the aforementioned apparent uniformity of hosts, this latter symptom suggests that certain lambs had a greater resistance to the toxin. This resistance may even have masked the potentialities of seemingly innocuous ticks. According to records at the Kamloops laboratory, paralysis in cattle is invariably caused only by

clusters of ten to 50 ticks and it is doubtful whether these animals could be paralysed by solitary specimens. However, not all animals with heavy infestations will become paralysed — suggesting again an individual resistance.

The data for lambs 10, 13, 14, 18, and 19 substantiate a variation in virulence among ticks. At the same time, there is an indication that a paralysed animal is so weakened that it may then be affected by ticks, which on a healthy animal, would not be considered virulent. This is evident in animals on the range which often remain prostrate for several hours until the last ticks are removed, and then make a rapid recovery. This could be the case in lamb 13.

Lamb 9 presented an interesting opportunity for a further experiment in that paralysis commenced when the two engorging ticks were only half-replete. The ticks were transferred to lamb 1, which, though having been subjected to ticks, had not yet been paralysed. The virulent ticks attached, and dropped within a day—but did not cause paralysis. Similar results occurred in a previous year when a partially fed tick from a paralysed child was induced to attach to a mouse, whereupon it mated and fed rapidly without harm to its second host. Again there are too many unknowns to establish a reason for this behaviour. It appears that a virulent tick can paralyse only the host upon which it commences to engorge.

In summary, it is assumed that tick paralysis is brought about in the host by a toxin secreted by the engorging tick. It appears that the production of tick paralysis in an animal depends on a combination of host susceptibility and tick virulence; and that where the host is relatively resistant, as in sheep and cattle, only a certain portion of rapidly feeding ticks produce the symptoms, whereas in humans, considered to be more susceptible, solitary, slow-feeding ticks are sufficient to cause paralysis. The conflicting evidence concerning the varying resistance of the host and the unknown virulence of the ticks makes it difficult to arrive at any conclusion.

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A REVIEW OF STUDIES ON THE SYSTEMIC CONTROL OF LIVESTOCK INSECT PARASITES[1]

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If, without causing harm to the animals, it were possible for a stockman to introduce into the diet of his livestock some substance that was toxic to bloodsucking arthropods feeding upon these animals, he would find a solution to one of the important problems of animal husbandry. Economic entomologists have recently devoted a great deal of effort toward the attainment of this ideal, and the investigations seem to indicate that it may be possible to achieve it.

However, the problem is not simple. Many difficult biochemical and toxicological factors must be studied and their roles elucidated before the problem can be solved. Because of these factors, the entire matter must be approached with caution. A full discussion of these aspects is beyond the scope of this paper because it is my intention only to review some of the more important studies that have been made in the past.

The first important contribution is that of Knipling (1938), who reported

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that, when cattle ingested phenothiazine, horn fly larvae did not develop in the manure subsequently eliminated by such animals. Bruce (1939) confirmed these findings and established the dosage levels required for maximum control. Creighton (1943) made an unsuccessful attempt to control chicken lice by adding sulphur to the concentrate portion of the poultry diet.

The recognition of the insecticidal properties of DDT and BHC instituted widespread investigations of the insecticidal properties of many organic chemicals, and the systemic aspect was not neglected. Linquest (1944) reported that oral ingestion by rabbits of either DDT or pyrethrum in massive dosages was toxic to bed bugs subsequently fed on the rabbits. de Meillon (1946) made a similar observation concerning the bed bug feeding on rabbits that had ingested the gamma isomer of BHC. This observation was confirmed by Wilson (1948), who administered it orally as a control for tsetse flies on cattle.

J. D. Gregson (personal communication) noted that ingested gamma isomer of BHC was toxic to ticks and lice feeding on horses, cattle, and chickens. This observation, together with the published data of deMeillon and Wilson, provided the basis for an extensive series of tests conducted at the Kamloops laboratory in the summer of 1949.

During that summer I carried out a test of the gamma isomer of BHC, using domestic hogs and their natural parasite, *Haematopinus suis* (Linn.), as experimental animals. Single dosages at the level of 40 milligrams per kilogram of animal body weight provided 100 per cent. control of the parasite for about eight to ten days. Daily dosages at the level of 20 milligrams per kilogram for four days were required to produce similar results. However, a series of toxicity tests, with guinea pigs as the test animals, showed that daily treatment at dosage levels of 20 milligrams per kilogram was a dangerous practice. It is perhaps invalid to extend experimental results determined with one animal species to other, dissimilar species; but since it is economically impossible to conduct satisfactory toxicity tests with animals such as cattle, horses, and hogs, it was decided that in this instance the extension was justifiable. Therefore these tests were considered to have indicated that this treatment was not a valid control method.

In the meantime other workers had conducted preliminary tests with many other chemicals. Knipling (1948) published the results of an extensive series of tests involving many different chemical compounds in an attempt to control the body louse, *Pediculus humanus corporis* Deg., feeding on rabbits. The most promising of the compounds tested was 2-pivalyl-1, 3-indandione. Babers (1949) published a favourable report of tests conducted with this chemical, using the same experimental animals.

This review of the systemic aspect of livestock parasite control is brief; however, it indicates that the problem is not being neglected and suggests a concrete basis for its solution.

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NOTES ON SOME PTINIDAE OF BRITISH COLUMBIA (COLEOPTERA)[1]

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The writer has made observations during the past year and a half on insects infesting stored products in flour warehouses, feed mills, grain elevators, and other food storage or food processing plants in British Columbia. One of the most important groups of insects found in such places are the Ptinidae, or spider beetles. This paper deals with the insects belonging to this group.

Spider beetles are important pests of cereal products and seeds in storage in Canada. They attack practically all types of cereal and animal feeds. Most of the species found in Canada are able to survive the winter in protected habitats. The adults of some species are very prolific and the females frequently oviposit through the mesh of cotton sacks (Gray, 1933). The larvae complete their development within the food material in approximately two to three months at summer temperatures. When mature, the larvae frequently leave the food product and burrow into the timbers of the warehouse before pupation. The scarring produced by the larvae is positive evidence of previous spider beetle infestation (Gray, 1942).

Hinton (1941) recorded 21 species of Ptinidae as pests, most of these causing damage to stored products of various kinds. Manton (1945) reported that 15 species had been recorded in the British Isles as infesting stored products or as present in buildings where such products are normally kept. The writer has found 11 species in British Columbia, ten determined, and one uncertain.

Ptinus ocellus Brown [=*P. tectus* auct.], the Australian spider beetle, is the most widespread and abundant of the ptinids in British Columbia. In British Columbia this species was first reported from Victoria in 1927 by W. Downes (Brown, 1940). Spencer (1942) reported that it was sent to him in 1926 from Prince Rupert, where it was infesting fish meal on a wharf "in the thousands." In Canada this species appears to be restricted very largely to the coastal regions. It is widely distributed throughout British Columbia, including Vancouver Island, and was found in 43 per cent. of the places visited. Due to the mild climate this species is active throughout the year in this area.

P. ocellus is a pest of considerable economic importance in many parts of the world. Hinton (1941) stated that it is the most generally distributed of the warehouse pests in Great Britain, having become established there in 1901. It is also a pest of major importance in Germany and several other European countries. It has been reported from a variety of products, including cayenne pepper, chocolate powder, desiccated soup, cacao, nutmegs, almonds, ginger, figs, sultanas, dried pears, dried apricots, beans, rye, fish food, maize (Hatch, 1933), and fish meal (Brown, 1940). The writer has found it infesting pastry flour, fish meal, turkey starter, calf meal, and mixtures of oats, bran, flax, rye, and wheat. The writer has successfully reared this species on nearly all of the above mentioned products in the Vancouver laboratory and on a mixture of whole wheat flour and brewers' yeast.

The writer, in test work, has found that the larvae can complete their development on relatively small amounts of food. When food is lacking the larvae eat their excreta and the glandular material used in the formation of the pupal cells (Gunn and Knight, 1945). Both larvae and the adults can survive for a long time without access to water if the moisture content of the food is reasonably high. However, under laboratory conditions, eggs are not produced by

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the adults if free water is not available (Ewer and Ewer, 1942). The writer has also found this to be true.

Ptinus fur (L.), the white-marked spider beetle, ranks second in importance in British Columbia. It is widely distributed throughout Canada, but seems to be more abundant in British Columbia than in the other provinces (Brown, 1940). In the United States this species was first reported in 1869 and losses were recorded in flour in Canada as early as 1893 (Gray, 1942). This species feeds on a variety of dried and decaying animal and vegetable matter. In this Province, *P. fur* has been found in 11.7 per cent. of the establishments inspected, usually in association with *P. ocellus*. This species has also been reared in the Vancouver laboratory on whole wheat flour and brewers' yeast.

The species that follow have been found on only a few occasions and are not widely distributed in British Columbia. *Ptinus raptor* Sturm is thought to be of European origin and is now almost world-wide in distribution (Hinton, 1941). In Canada it was first taken at St. Peters, Nova Scotia, in 1930 by M. L. Prebble (Brown, 1940). Later Gray (1942) found that this species was the most abundant spider beetle in the warehouses of Nova Scotia, New Brunswick, and much of Quebec. This species was found by the writer infesting flour in warehouses at Nelson, Vancouver, and Victoria.

In Canada *Ptinus villiger* (Reit.), the hairy spider beetle, was taken first in Manitoba in 1915, is well established in the Prairie Provinces, and also occurs in Ontario and Quebec and to a lesser extent in the Maritime Provinces (Gray, 1933). The losses to cereal products caused by this spider beetle far exceed those by any other member of the group (Gray, 1942). In British Columbia this species was first reported in 1933. The writer found it at three scattered points in 1950: Rossland, Creston, and Vancouver.

The writer found *Trigonogenius globulus* Solier, the globular spider beetle, infesting three warehouses in Vancouver and one in Victoria. Great numbers were found in Victoria, and in one of the warehouses in Vancouver a heavy infestation was encountered on sacks containing cracked corn. Brown (1940) reported that the species is confined largely to the Pacific region of North America. It has been reared in the Vancouver laboratory on the same medium as *P. ocellus*.

In British Columbia *Eurostus hilleri* (Reit.) [=*E. alienus* Brown] was found first by H. E. Gray at Kamloops in 1939 (Brown, 1940). During the past year the writer found it in small numbers in two warehouses: one in Victoria and one in Vancouver. Hinton (1941) recorded it only in Japan, Great Britain, and Canada. According to Manton (1945) it has become established in England in recent years and appears to feed mainly, if not entirely, on rat and mouse droppings. Where the writer found this insect, no appreciable amounts of droppings were visible. It has been reared in the Vancouver laboratory in small numbers on whole wheat flour and brewers' yeast. On this medium the time required for development for *E. hilleri* is similar to that for *P. ocellus*.

Howe (1949) reported that the fertility of this species is very low, less than 50 eggs per female being laid in the laboratory. Results in the Vancouver laboratory confirm Howe's findings. This insect is not likely to become a serious pest in this province.

Ptinus bicinctus Sturm was recorded by Hinton (1941) from Europe, North Africa, and North America. It was taken by the writer in association with *P. fur* at Rossland, B.C., in June, 1950, infesting flour in a warehouse. According to Brown (1940), it is rarely taken on this continent and the capture reported here appears to be the first record of *P. bicinctus* in British Columbia. It has been found previously in Alberta, Ontario, Quebec, and Nova Scotia (Brown, 1940).

Specimens of *Niptus hololeucus* (Fald.), the golden spider beetle, were

found by the writer in four Vancouver warehouses. Spencer (1942) reported that this species was found by H. B. Leech in 1936 at Fernie, B.C. Brown (1940) reported that it had been taken in Nova Scotia, New Brunswick, Quebec, Ontario, and Alberta, and at Fernie and Victoria in British Columbia. Hinton (1941) recorded it as nearly cosmopolitan but absent in the tropics. It has been a pest of importance in Europe for some time.

Ptinus latro Fab. has been taken by the writer on three occasions. The exact locality of specimens taken in 1950 is uncertain, but others were found in 1951 in warehouses in Vancouver and in Mission, B.C. These appear to be the first records of this insect in British Columbia. In Canada this species was first taken in Montreal in 1937. It was found again in Montreal in 1939 and in Toronto in 1940 (Brown, 1940). It is similar in appearance to *P. hirtellus*, the brown spider beetle. Hinton recorded it as cosmopolitan in distribution.

One specimen of *Mezium affine* Boiel. was found in a warehouse in Vancouver by the writer. In the same area in the warehouse were several of three other species, namely, *Trigonogenius globulus*, *Niptus hololeucus*, and *Ptinus ocellus*. *M. affine* was reported previously by Prof. G. J. Spencer, University of British Columbia (verbal communication, 1951), as having been taken in dwelling places and being reared in his laboratory on fox chow. Hinton (1941) reported the distribution of *M. affine* as being restricted to Europe and North Africa. Brown (1944) recorded that it occurred in the United States as early as 1904 and is convinced that all specimens from Canada that have been recorded as of *M. americanum* (Lap.) should be referred to as *M. affine* Boiel. The latter species is found in northeastern United States as well, whereas *M. americanum* has a more southern distribution, being recorded from Texas and Florida.

Spencer (1942) also reported having taken *Sphaericus gibboides* (Boiel.) in British Columbia and rearing it successfully in the laboratory. Hinton (1941) reported this species from California, southern Europe, and North Africa.

There is some doubt as to the identity of the other species of spider beetle found in British Columbia. Two specimens were taken in Vancouver by the writer, which have been tentatively identified by W. J. Brown as of *Ptinus* sp., probably *hirtellus* Sturm, possibly *latro* Fab. If it is the brown spider beetle, *P. hirtellus*, it is a cosmopolitan species (Hinton, 1941), reported from many localities in the United States but previously recorded in Canada only from Toronto and Kingsville, Ontario, and at Lunenburg, Nova Scotia (Brown, 1940).

The writer is indebted to Mr. W. J. Brown, Systematic Entomology, Division of Entomology, Ottawa, for identification of species.

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THE ENTOMOLOGICAL SOCIETY OF CANADA[1]

W. A. Ross
Ottawa, Ontario

I believe members of the Entomological Society of British Columbia are aware that at the 87th Annual Meeting of the Entomological Society of Ontario, held at Guelph on November 1-3, 1950, it was decided to form a national society to be called The Entomological Society of Canada. This very important event in the history of Canadian Entomology was the outcome of several years of study by a committee set up to implement the oft-expressed desire of Canadian entomologists to have a truly national association in this country. I shall not take the time to discuss the problems the committee encountered; suffice is it to say that all of them were happily solved.

Although the constitution of The Entomological Society of Canada has not yet been written and approved, I can give you, on the basis of the resolution adopted at the Guelph meeting, an outline of the important functions of the association.

The new society will serve not as the parent of but simply as the link between the Acadian Entomological Society, the Entomological Society of Quebec, the Entomological Society of Ontario, the Entomological Society of Manitoba, the Entomological Society of British Columbia and any others that may be established. It seemed evident to those of us who had given careful thought to the advancement of the science of entomology by learned societies, that such advancement could be brought about most successfully in this country of ours, with its great distances and with its many local variations and needs, by placing the greatest emphasis on the fostering of regional societies. Therefore, each regional society will be autonomous, with authority to set up its own constitution and by-laws and its membership and annual dues, and to publish, if it so desires, its own annual report, *e.g.*, the annual reports of the Entomological Society of Ontario, the Entomological Society of Manitoba, and the Entomological Society of British Columbia. (There is a little matter in connection with annual reports which I should deal with here. All members of the Entomological Society of Canada as well as subscribers to the Canadian Entomologist will continue to receive the Annual Report of the Entomological Society of Ontario. We have to thank the Ontario Society and the Ontario Department of Agriculture for this generous arrangement. But it does not follow that other regional societies will want or be able to do the same sort of thing. What they do with their annual reports in the matter of distribution, etc., will be entirely their own business.) The national organization will promote the welfare of the regional entomological societies and will encourage the formation of others. It will do nothing that might conceivably weaken them and in no sense will it dominate them. In brief, it will serve as the link in a Canadian commonwealth of regional autonomous societies.

[1]Presented at the 50th Anniversary Meetings of the Entomological Society of British Columbia in Vancouver, June 14-16, 1952.

The Entomological Society of Canada publishes The Canadian Entomologist and it shares this responsibility with the Entomological Society of Ontario for two good reasons, one historical and sentimental, and the other financial: (1) It should never be forgotten that the Entomological Society of Ontario founded The Canadian Entomologist and was responsible for its publication for 82 years; (2) By maintaining a direct and financial interest in The Canadian Entomologist, the Entomological Society of Ontario is still eligible for the Ontario Government grant which will be used as a contribution to the cost of printing The Canadian Entomologist.

When the constitution is drafted and adopted, I hope it will be possible to say that membership in the Entomological Society of Canada is open to all persons, no matter where they live, whose pursuits or studies are connected with entomology or who are interested in natural history. Be that as it may, in the meantime I can say that all entomologists in Canada are eligible for membership in the Canadian Society. But, again with the idea of fostering and featuring the regional society, there are two classes of fees:—

1. For entomologists in an area not served by a regional society, for example Saskatchewan, the membership fee for 1951 is $4.00 and this is payable to our Treasurer, Mr. A. B. Baird.
2. For entomologists who are members of regional societies, the membership fee in the Entomological Society of Canada is $3.00, payable to the Secretary-Treasurer of one of the local societies.

It follows, therefore, that most of the dues will be collected by the regional societies. I suppose it is scarcely necessary to point out that the $3.00 fee is additional to the local society fee and that the size of the local fee is entirely the affair of the regional organization.

The annual meeting of the National Society will always be held jointly with the annual meeting of one of the regional societies, *e.g.*, with the Entomological Society of Ontario in 1951, possibly with the Entomological Society of Quebec in 1952, with the Entomological Society of Manitoba in 1953 and so on. This will avoid the holding of too many major entomological meetings in Canada, will be less apt than any other arrangement to weaken the attendance at regional society meetings and will make it possible for most Canadian entomologists to attend at least one national meeting every several years. Incidentally the first annual meeting of the Canadian society will be held jointly with the 88th Annual Meeting of the Entomological Society of Ontario, November 1, 2, and 3, in Ottawa —fittingly—in Ottawa, the capital of Canada, and also the headquarters of the national society. I sincerely hope it will be possible for a number of your members to attend this historic meeting.

I should like to say a special word about our journal, The Canadian Entomologist. As I have already mentioned, it is the responsibility of the Entomological Society of Canada to publish this journal regularly, to maintain high standards in it, and to keep it solvent, but the editor of the journal and the other society officers cannot carry this responsibility without the whole-hearted support and co-operation of the regional societies. Each regional society, therefore, must exert every effort to enlist practically 100 per cent. of its members in the Entomological Society of Canada and to provide the editor of the journal with papers of high quality. The future status of The Canadian Entomologist and of the Entomological Society of Canada will be determined very largely by the amount of support afforded them by the regional societies and by all entomologists in this country.

LIST OF THE ELATERIDAE OF BRITISH COLUMBIA

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Some of the species of the coleopterous family Elateridae, commonly known as wireworms or click beetles, have long been known as important insect pests of agricultural crops. In connection with the research on the life history and control of these economic forms, it is also desirable to learn as much as possible about their distribution, as well as that of related non-economic species. Distribution records are obtained by collecting and publishing the results. There are all too few publications of this sort. The present list has been compiled from a rather extensive list of articles and references to the Coleoptera of British Columbia, brought together by M. H. Hatch, from original descriptions, from revisional publications, and from recent collections made or seen by the author. The earliest list of Elateridae for British Columbia is one of 28 species recorded from Vancouver Island by LeConte in 1869. This was followed by other lists by LeConte and many others until 1927-1928, when G. H. Hardy published two lists, one of species from Garibaldi Park and another of species on Vancouver Island.

The author has been collecting this family in the Pacific Northwest since 1917, as well as receiving considerable material from other entomologists for determination. Many private and semi-official collections have been checked, including the very fine and extensive collection of Gordon Stace-Smith of Creston, B.C. In a short visit to Vancouver Island in June, 1950, the writer collected 17 species of Elateridae adults in two days on the home grounds of his host, Kenneth M. King, at Victoria, as an example of the concentration of species that sometimes occurs under favorable circumstances.

Altogether, there appear to be at least 74 authentically determined species on Vancouver Island alone, of which 19 species have been recorded from the Island only, although they may also occur on the mainland. There are 129 species listed as present on the mainland of British Columbia, 55 of which are also found on the Island. The list here appended includes a total of 150 species of Elateridae for the Province of British Columbia. From the literature and from collections made in adjoining areas, there are probably about 25 more described species that should eventually be recorded as occurring in British Columbia. It is a very large Province and, undoubtedly, many new species are yet to be discovered. This paper is written in the hope that it will provide an incentive for further collecting and the discovery of new species.

Acknowledgment is due to the following workers for studies or for material collected in the group on which this list is based: E. C. Van Dyke, W. J. Brown, H. B. Leech, Ralph and George Hopping, K. M. King, M. H. Hatch, Gordon Stace-Smith, Richard Guppy, C. L. Nielson, D. J. Finlayson, H. R. MacCarthy, W. H. A. Preece, R. H. Handford, and others whom I may have overlooked.

LIST OF ELATERIDAE OF BRITISH COLUMBIA

* Species occurring on Vancouver Island only.
** Species occurring on the mainland only. Unmarked species occur on both the island and mainland.
"auct." as used here refers to a name used erroneously by the determiner, in most cases eastern names of species later described as western.

Lepidotus Stephens, 1830
(*Lacon* Cast. *Adelocera* auct.)
**brevicornis (LeC.)
**obtectus (Say)
profusus (Cand.) (*cavicollis* (LeC.))
rorulentus (LeC.) (*prysolepis* auct.)
**sparsus (Cand.)

Alaus Esch., 1829
melanops Lec. (*oculatus* auct.)

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Drasterius Esch., 1829 (*Aeolus* auct.)
debilis Lec.
**dorsalis (Say) (*mellillus* (Say), *comis* (LeC.)

Limonius Esch., 1829 (*Pheletes* Kies.)
**aeger LeC.
*bicolor Van D.
canus Lec. (*discoideus* LeC.)
*californicus (Mann.) (*occidentalis* LeC.)
consimilis Walk. (*nitidicollis* LeC.)
**crotchi Horn
*humidus Lane
infuscatus Mots.
nitidulus Horn
**pectoralis LeC.
**rufihumeralis Lane
**seminudus Van D.
subauratus LeC.
**venablesi Wick.

Elathous Reitt., 1890
nebulosus (Van D.)

Athous Esch., 1829
*imitans Fall
nigropilis Mots.
pallidipennis Mann.
rufiventris (Esch.) (*ferruginosus* (Esch.))
scissus LeC.
vittiger LeC.

Ctenicera Latr., 1829 (*Corymbites* Latr., *Ludius* Esch.)
aereipennis (Kby.)
angularis (LeC.)
angusticollis (Mann.) (*fraterna* (LeC.), *spectabilis* (Mann.))
**bipunctata (Brown)
bombycina (Germ.) (*fallax* auct.)
callida (Brown) (*inflatus* auct.)
**carbo (LeC.)
columbiana (Brown) (*propola* auct., *furcifer* auct., *nubilis* auct.)
comes (Brown)
**conjungens (LeC.)
**crestonensis (Brown)
**festiva (LeC.) (*cruciatus* auct., *pulcher* auct.)
*diversicolor (Esch.) (*rotundicollis* auct.)
**funerea (Brown) (*semivittatus* auct., *fusculus* auct.)
*furtivua (LeC.) (*monticola* auct.)
**glauca (Germ.) (*inflatus* auct.)
hoppingi (Van D.)
**kendalli (Kby.) (*aeneicollis* auct.)
**laricis (Brown)
*lateralis (LeC.)
lobata (Esch.) (*caricina* (Germ.), *telum* (LeC.), *tarsalis* auct.)
**lutescens (Fall)
**maura (LeC.)
**mendax (LeC.)
**moerens (LeC.)
**montana (Brown)
**morula (LeC.)
nebraskensis (Bland.)
*nigricans (Fall)
**nigricollis (Bland.) (*vernalis* auct.)
**ochreipennis (LeC.)
*opacula (LeC.)
**protracta (LeC.)
**pruinina (Horn) (*noxia* (Hysl.))
pudica (Brown) (*hieroglyphicus* auct.)
**pygmaea (Van D.)
resplendens (Esch.)
**rupestris (Germ.)
sagitticollis (Esch.) (*insidiosa* auct.)
**semimetallica (Walk.)
**silvatica (Van D.)
**stricklandi (Brown)
suckleyi (LeC.)
**triundulata (Rand.)
*uliginosa (Van D.)
**umbricola (Esch.) (*rudis* (mots.))
umbripennis (LeC.) (*gracilor* (LeC.))
**vidua (Brown)
**volitans (Esch.)
weidti (Angell)

Eanus LeC., 1861 (*Paranomus* Kies.)
**albertanus Brown
**decoratus (Mann.)
granicollis Van D.
striatipennis Brown

Hemicrepidius Germ., 1839 (*Asaphes* Kby.)
morio (LeC.) (*dilaticollis* auct.)
oregonus (LeC.)
*tumescens (LeC.)

Hypolithus Esch. 1829 (*Cryptohypnus* Esch, *Hypnoidus* Dillw. pars.)
**bicolor Esch. (*lucidulus* (Mann.))
funebris (Cand.) (*planatus* auct.)
**glacialis (Van D.) (*grandicollis* auct.)
**hyperboreus (Gyll.)
**impressicollis (Mann.) (*abbreviatus* auct.)
**nocturnus Esch.
**squalidus (LeC.)

Negastrius Thom., 1859 (*Cryptohypnus* Esch, *Hypnoidus* Dillw. pars.)
caurinus (Horn)
**gentilis (LeC.)
**manki (Fall)
*musculus (Esch.)
**ornatus (LeC.)
**pectoralis (Say)
**striatulus (LeC.)
**tumescens (LeC.)

Dalopius Esch., 1829 (*Dolopius* auct.)
**assellus Brown
*corvinus Brown
**fucatus Brown
**gartrelli Brown
**insolens Brown
insulanus Brown (*lateralis* auct.)
**maritimus Brown
spretus Brown
**suspectus Brown
tristis Brown

Sericus Esch., 1829 (*Sericosomus* auct.)
incongruus (LeC.) (*brunneus* auct.)

Agriotes Esch., 1829
**apicalis LeC.
**criddlei Van D.
ferrugineipennis LeC. (*fucosus* auct.)
*lineatus (L.)
*obscurus (L.)
*opaculus LeC.
sparsus LeC.
**tardus Brown
theveneti Horn

Agriotella Brown, 1933 (*Betarmon* auct.)
*columbiana Brown
occidentalis Brown
Ampedus Dej., 1833 (*Elater* Esch., nec Linn.)
**apicatus (Say)
**behrensi (Horn) (*cordifer* auct.)
bimaculatus (Van D.)
**brevis (Van D.)
carbonicolor (Esch.)
columbiana Brown (*varipilis* auct., *cordifer* auct.)
**hoppingi (Van D.)
**moerens (LeC.)
nigrinus (Hbst.) (*anthracinus* auct.)
oregonus (Schffr.)
phoenicopterus (Germ.)
**pullus (Germ.)
rhodopus (LeC.)
**ursinus (Van D.)
Megapenthes Kies., 1858
caprella (LeC.)
**nigriventris LeC.
**stigmosus (LeC.)
tartareus LeC.
Melanotus Esch., 1829
oregonensis (LeC.)
Cardiophorus Esch., 1829
**fenestratus LeC.
*latiusculus Esch.
*longior LeC. (*longulus* err.)
**mimeticus Horn (*edwardsi* auct.)
**pubescens Bl.
tenebrosus LeC. (*amplicollis* auct.)
**tumidicollis LeC.
Horistonotus Cand., 1860
**sufflatus (LeC.)

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THE EFFECT OF CERTAIN INSECTICIDES ON THE GERMINATION AND GROWTH OF ONIONS
I. INSECTICIDES APPLIED TO THE SOIL[1]

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Introduction: The onion maggot, *Hylemya antiqua* (Meig.), has for many years caused serious damage to onion crops throughout the interior of British Columbia. In 1950, insecticide trials were undertaken at the Kamloops laboratory to provide a more satisfactory and less expensive control for this pest than the commonly used calomel seed-treatment. As an extensive review of the literature revealed that practically no work had been done on the phytotoxicity of the

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insecticides to this crop, study was also directed toward whether certain insecticides when applied to the soil at commonly used rates would affect the onions.

The results of the latter study are dealt with in this paper. In a following paper, D. G. Finlayson discusses the effects of some of the newer insecticides when applied as seed treatments.

Methods and Materials: The experiment was conducted in clay pots in an insectary, so that attack by the onion maggot or other insects was prevented. There were six insecticidal treatments, the amounts being calculated on an area basis as follows:—

1) Dowfume W-85 emulsion (containing 83 per cent. by weight of ethylene dibromide) applied at the rate of nine U.S. gallons per acre.
2) Dowfume W-85 emulsion applied at the rate of 4.5 U.S. gallons per acre.
3) Aldrin, 2½ per cent. dust, applied at the rate of 100 pounds per acre.
4) Technical chlordane, 5 per cent. dust, applied at the rate of 200 pounds per acre.
5) Lindane, 1 per cent. dust, applied at the rate of 100 pounds per acre.
6) DDT, 5 per cent dust. applied at the rate of 200 pounds per acre.

These six treatments and a check were replicated four times, giving a total of 28 pots. Each treatment was applied once, the dust or the emulsion being sprinkled on and thoroughly mixed with sufficient uncontaminated, uniform, sandy loam soil for one seven-inch clay pot. Fifteen onion seeds of the Yellow Globe Danvers variety were planted at uniform depths, and at uniform spacing, in each pot. The pots were then set out in a randomized block design in an insectary that was covered with 14-mesh galvanized wire screen. Equal amounts of water were applied daily to all pots.

In determining the effects of the treatments on the onion seeds and seedlings, emergence of the plants from the soil, weight, height, colour, uniformity of the top growth, and plant survival were the criteria used. The number of emerged plants was recorded from thrice-weekly counts for each pot. Growth was determined by noting the total weight of all the plants in each pot at harvest and calculating the average. Notes were also made during the growing season and at harvest on height, uniformity of top growth, and variations in colour of the top growth.

Results and discussion: Table I shows the effects of the various treatments on total plant weight, average plant weight, and total number of plants. None of the insecticides used with the possible exception of chlordane, adversely affected the emergence or growth of onion seedlings. All treatments, except that of chlordane, exceeded the check treatment in the number of plants emerging and in the total weight of plant material produced. DDT and lindane produced slightly smaller plants than the checks, whereas the other treatments produced plants that were as large as or larger than those in the check. The total plant weights suggest that aldrin and the 4.5-gallon rate of ethylene dibromide stimulated emergence and plant growth. DDT, the nine-gallon rate of ethylene dibromide and lindane, in that order, also showed indications of favourable effects, but to a lesser degree. However, in each instance the favourable effect was due to stimulation of emergence rather than of growth.

Each of the treatments except chlordane stimulated emergence somewhat. During the first three weeks, emergence and plant survival were slightly greater for ethylene dibromide at nine gallons and 4.5 gallons. The chlordane caused a high mortality after emergence. The aldrin had a delaying effect on emergence for the first twelve days, later, emergence and growth appeared to be stimulated.

The DDT and lindane treatments appeared to hinder rather than promote growth.

Although none of the results of this experiment was statistically significant the results of some of the treatments appeared fairly definite. In some instances they support and in other instances contradict, statements made by other workers who have written on the phytotoxicity of insecticides. Much of this published material is so contradictory that it appears to be meaningless. Thorough investigation of such factors as plant species and variety, soil fertility, soil texture, soil moisture, fertilizers, climatic conditions, and their relationship to insecticides is urgently required as a prerequisite to further work on phytotoxicity. A compilation of all the material on the phytotoxicity of insecticides and a set of standard procedures to permit consistent results are necessary before sound experimentation of this type can be undertaken.

Summary: Five insecticides were incorporated into the soil in pots to find the effect on the germination of onion seeds of the Yellow Globe Danvers variety and on the growth of the resulting plants. All of the treatments except one produced more total plant material than the checks, but none was statistically better or worse than the untreated check.

Acknowledgments: The author acknowledges with thanks the assistance given by Dr. R. H. Handford, Officer-in-Charge, Field Crop Insect Laboratory, Kamloops, B.C., in the planning of the experimental work and in the writing of this paper. The author also wishes to express his appreciation to Dr. G. H. Harris, Professor of Plant Nutrition, Department of Horticulture, University of British Columbia, for advice on the statistical analysis of the data.

TABLE I.

Effect of one soil application of each of various insecticides on onion plants in four replications.

Treatment	Application Rate per Acre	Total Number of plants		Weight of Plants at Harvest	
		Emerged	At Harvest[1]	Average[2] (grams)	Total[3] (grams)
Chlordane 5% dust	200 lb.	27	21	0.573	12.0
Check	nil	30	27	0.477	12.9
Lindane 1% dust	200 lb.	34	31	0.465	14.4
Dowfume W-85	9 U.S. gal.	35	32	0.478	15.3
DDT, 5% dust	200 lb.	37	34	0.467	15.9
Aldrin, 2½% dust	100 lb.	36	33	0.507	16.7
Dowfume W-85	4.5 U.S. gal.	38	32	0.559	17.9

[1]Difference necessary for significance at 5% level—14.
[2]Difference necessary for significance at 5% level—0.156.
[3]Difference necessary for significance at 5% level—6.4.

THE EFFECT OF CERTAIN INSECTICIDES ON THE GERMINATION AND GROWTH OF ONIONS

II. INSECTICIDES APPLIED TO THE SEED[1]

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INTRODUCTION

In 1949, it appeared that the recommended calomel seed-treatment did not satisfactorily control the onion maggot, *Hylemya antiqua* (Meig.), in seedling onions in the interior of British Columbia. Because of this, and its excessive cost, an investigation of the control of this pest with some of the newer insecticides was initiated in 1950. Analyses of yield data showed significant differences between various treatments. These differences were not all directly attributable to the attack of the maggots, since some treatments produced yields almost twice as great as others with almost similar percentage damage. The lower yields appeared to occur where insecticides had been applied either directly to the seed or to the seed trench.

To investigate this point, germination tests, the results of which are presented below, were conducted in the greenhouse during the winter of 1950-51. Further tests were conducted in the laboratory throughout the summer of 1951.

METHODS AND MATERIALS

The chemicals investigated were wettable powders of DDT, toxaphene, BHC, chlordane, Aldrin, and dieldrin; emulsible concentrates of aldrin and dieldrin; and powdered calomel (mercurous chloride). These were applied in three ways:—

Stirring in slurries of wettable powder. Onion seeds were treated with a 25 per cent. concentration of actual insecticide in water for each of the following: DDT, Toxaphene, BHC, chlordane, aldrin, and dieldrin. The seeds were stirred into the slurry for 5 minutes and the mixture was then poured through a 20-mesh copper screen to drain off the excess liquid. The seeds were placed on paper towelling to dry and were agitated periodically by means of a glass rod to prevent them from adhering to one another, so that none of the chemical coating might be removed in separating the seeds.

Dipping in emulsions. The seeds were stirred into a 5 per cent. emulsion of each of aldrin and dieldrin for 1 minute, the mixture was then poured through a 20-mesh copper screen and the seeds were placed on paper towelling to dry.

Coating seed with dry powder. The seeds were first soaked in water for 5 minutes, and then mixed with an equal weight of calomel. When as much of the calomel as possible had adhered to the seeds, they were separated from the powder by screening. This procedure is commonly recommended for controlling the onion maggot.

In the greenhouse the seeds were grown in 8-inch flower pots and each of the 10 treatments was replicated 5 times. Each replicate (*i.e.*, 10 pots) was set up as a randomized block.

Seeding was done by hand, 100 seeds per pot. These were sown in concentric circles with about half an inch between seeds and about the same distance between circles.

The first germination count was made 8 days after the first seedlings began to appear. Two additional counts were made at intervals of 10 days. Although daily recording might have given higher counts the germinations obtained by the above method indicated those seedlings that had grown beyond the period when food was supplied by the seed. The count at which the maximum number of plants was recorded was considered the total germination for the treatment.

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Throughout the growing period the plants were checked periodically for toxicological symptoms. Conclusions were based on comparisons involving three aspects of growth: the root and leaf systems, the average green weight per plant, and the average dry weight per plant. The average green weight per plant was determined by carefully removing all plants from the pots after allowing the soil to become slightly dry, and then washing the clinging soil from the plants by immersing them in warm water. After the excess moisture had been removed they were weighed as a group for each pot and the average weight per plant was calculated. The average dry weight per plant was obtained by placing the plants in a warming oven at 80°C. until a constant weight was obtained.

In the laboratory tests wettable powders and emulsions were applied to seed of a different lot from that used in the soil tests. In this series, samples of ½ oz. of onion seed were treated with either a 25 per cent. concentration of actual insecticide in water from a wettable powder or a 5 per cent. emulsion from an emulsifiable concentrate. The following numbers of ounces of actual insecticide adhered to one pound of onion seed:

DDT (w.p.)	3.5
BHC (w.p.)	4.0
aldrin (w.p.)	2.5
dieldrin (w.p.)	2.1
chlordane (w.p.)	4.1
toxaphene (w.p.)	4.1
aldrin (emul.)	0.16
dieldrin (emul.)	0.07
calomel (approx.)	16.0

Germination tests were conducted periodically to determine whether storage of the chemically treated seeds in an open glass container affected germination. Four tests were completed in all. In the first three, single lots of 25 seeds were placed in 10-cm. petri dishes on two thicknesses of No. 1 filter paper and covered. The filter paper was moistened daily so that the quantity of water could be better controlled. Germination counts were begun on the fourth day after the seeds were set out and continued daily for the following 12 days. The fourth test was similar to the previous three except that it was initiated 110 days after treatment and consisted of 5 replications. In addition to the germination counts observations were made periodically on development of the seedlings, colour, and general vigour of the plants.

RESULTS

Germination in Soil

A 5 per cent. emulsion of aldrin or dieldrin appeared to retard by 10-15 days the germination of the seeds planted in soil, aldrin seeming to be more harmful than dieldrin. In addition to the delay, the percentage germination was significantly low for both of these treatments (Table I). Although there was a significant decrease in the percentage germination of seed treated with BHC, no delay was evident. Toxaphene and dieldrin wettable powder treatments produced results similar to those for BHC. The percentage germination for the treatments is shown in Table I.

No significant differences were present between the remaining treated and the untreated series.

Effect of Storage on Germination

The effects of storing the chemically treated seeds in an open-topped glass container are shown in Tables II and III. In seeds tested immediately after treatment, germination was delayed by all chemicals except BHC. Tests begun 30 and 80 days after treatment did not exhibit this condition; however, in tests begun 110 days after treatment a marked delay in germination occurred for each treatment.

In the seeds stored 0 to 80 days, the percentage germination was highly significantly low for aldrin emulsion and significantly low for dieldrin emulsion; all the other treatments had similar germination to that of the untreated seeds. For seeds stored 110 days all treatments caused delay in germination; significant differences appeared as early as the second day

TABLE I.

Percentage germinations, in pots, of onion seed treated with various insecticides

Treatment	Ounces of actual insecticide adhering to one pound of seed	Germination	
		Total[1]	Percentage
Chlordane, 40 per cent. wettable powder	4.1	120	24.0
Untreated		117	23.4
Aldrin, 50 per cent. wettable powder	2.5	103	20.6
DDT, 50 per cent. wettable powder	3.5	91	18.2
Calomel, 100 per cent. dry powder	16 (approx.)	90	18.0
Dieldrin, 50 per cent. wettable powder	2.1	87	17.6
Toxaphene, 40 per cent. wettable powder	4.1	73	14.6
BHC, 50 per cent wettable powder	4.0 (BHC)	52	10.4
Dieldrin, 5 per cent. emulsion	0.07	41	8.2
Aldrin, 5 per cent. emulsion	0.16	19	3.8

[1]Difference necessary for significance: 5 per cent. level, 27.2.

after germination commenced (Table III). By the second day DDT wettable powder. BHC wettable powder, and aldrin emulsion each caused significantly lower germination than aldrin, dieldrin, and toxaphene wettable powders. Chlordane wettable powder and dieldrin emulsion were not significantly different from either of these groups. However, by the twelfth day of germination, DDT, BHC, toxaphene, aldrin emulsion, and dieldrin emulsion treatments each gave significantly low counts.

Characteristics of Growth in Soil

Periodical observations indicated that plants grown from treated seed did not differ from those from untreated seed, except those from seed treated with BHC or chlordane. Plants grown from BHC-treated seed were stunted and stocky, the leaf portion being two to four times thicker than in the untreated plants. Within a week after germination these plants exhibited chlorosis, and necrosis was developing. Several such plants were removed from the soil, all showing the following characteristics: short, stubby, primary roots; no secondary root system; no root hairs; and little or no bulb. Later examination proved that the roots from all plants grown from BHC-treated seed had similar symptoms. Plants grown from seed treated with chlordane appeared to have larger root and leaf systems than those of the checks.

The treatments did not cause significant differences in either the average green weight or the average dry weight of the onion plants. As a result of reduced germination, however, the grand total of green and dry weights was significantly reduced by treatment with BHC, toxaphene, aldrin emulsion, or dieldrin emulsion.

TABLE II.

Germination counts, in petri dishes, of treated onion seed after storage for 0, 30, and 80 days in open-topped glass containers.

Treatment	Ounces of actual insecticide adhering to one pound of seed	Germination counts at 1, 6, and 12 days for 25 seeds								
		0 Days' Storage			30 Days' Storage			80 Days' Storage		
		1	6	12	1	6	12	1	6	12
Chlordane, 40 per cent. wettable powder	4.1	6	23	24	10	22	22	4	19	24
Untreated		10	22	22	17	22	22	15	25	25
Aldrin, 50 per cent. wettable powder	2.5	0	23	24	9	19	21	3	15	20
DDT, 50 per cent. wettable powder	3.5	2	21	21	9	22	23	5	15	22
Dieldrin, 50 per cent. wettable powder	2.1	0	22	23	14	23	23	9	18	21
Toxaphene, 40 per cent. wettable powder	4.1	0	21	22	11	21	21	8	16	20
BHC, 50 per cent. wettable powder	4.0 (BHC)	17	24	24	10	16	20	6	14	22
Dieldrin, 5 per cent. emulsion	0.07	0	16	18	8	10	12	6	15	21
Aldrin, 5 per cent. emulsion	0.16	0	7	10	0	2	4	0	1	2

Growth Characteristics in Petri Dishes

The toxicological symptoms observed in the seedlings grown in petri dishes from treated seeds were more pronounced. As the petri dishes were covered to maintain moisture content, fumigation may have been a factor. The relative sizes of the seedling plants for these tests are shown in Fig. 1.

The symptoms produced by BHC were the most pronounced. Chlorosis was present from the time of germination of the seeds until the death of the plants. The length of the sprout in BHC-treated seed did not exceed ½ inch, even 10-12 days after germination. On the other hand, in the untreated series, the young plants had dark-green leaves, secondary roots and root hairs, and small bulbs; and the leaf had begun to straighten from the "loop stage."

Other treatments that caused some difference in the development of the seedlings were chlordane wettable powder, toxaphene wettable powder, and aldrin emulsion. The seedlings of chlordane-treated seed exhibited a lack of root hairs, slight chlorosis, and a thickening at the neck of the bulbs. The two other treatments caused exactly opposite conditions: seedlings from toxaphene-treated seed had poorly developed root hairs, whereas those from aldrin emulsion-treated seed had root hairs that were longer and more abundant than those of the untreated seedlings.

TABLE III.

Germination counts, in petri dishes, of treated onion seed after storage for 110 days in open-topped glass containers.

Treatment	Ounces of actual insecticide adhering to one pound of seed	Germination counts at 2, 4, 6, 8, 10, and 12 days for 125 seeds					
		2[1]	4	6	8	10	12[1]
Chlordane, 40 per cent wettable powder	4.1	19	50	80	97	102	104
Untreated		118	121	123	124	124	124
Aldrin, 50 per cent. wettable powder	2.5	29	52	81	91	108	109
DDT, 50 per cent. wettable powder	3.5	6	33	67	86	95	100
Dieldrin, 50 per cent. wettable powder	2.1	30	68	91	97	102	105
Toxaphene, 40 per cent. wettable powder	4.1	27	50	73	86	89	93
BHC, 50 per cent. wettable powder	4.0 (BHC)	11	27	36	75	88	98
Dieldrin, 5 per cent. emulsion	0.07	18	39	65	79	85	87
Aldrin, 5 per cent. emulsion	0.16	2	5	12	22	29	35

[1]Difference necessary for significance, 5 per cent. level:
second day, 16.9,
twelfth day, 23.6.

DISCUSSION

Although the percentage germination of the onion seed used in soil was far from satisfactory, the potential rates of germination of treated and untreated seeds were similar. The germination for untreated seeds averaged only 24 per cent., which is far below that required for commercial seed. Nevertheless, the germination of seed treated with BHC wettable powder, dieldrin wettable powder, toxaphene wettable powder, a 5 per cent. emulsion of aldrin, or a 5 per cent. emulsion of dieldrin was significantly lower than that of the checks. In the last two treatments it is thought that germination was not retarded by the insecticides themselves, but by the liquid solvent used in the emulsion concentrate. If this be so it could either act as a mechanical barrier to the moisture necessary to produce germination or have a lethal effect on the embryo within the seed.

Germination tests conducted in petri dishes substantiated the results obtained for treated seeds used in soil, this seed giving almost 100 per cent. germination in the checks. Here again the germination of seeds treated with BHC, toxaphene, a 5 per cent. emulsion of aldrin, or a 5 per cent emulsion of dieldrin was significantly lower than for the checks. However, for one additional treated series, that of DDT, germination was significantly lower than for the checks.

Throughout the series of tests to determine the effect of storage on chemically treated seeds there was a delay in germination of all treated

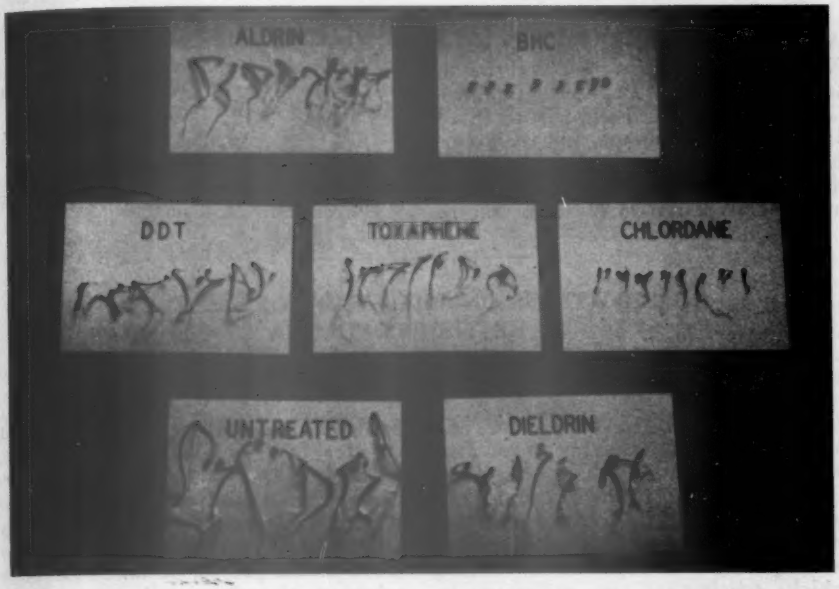

Fig. 1.—Growth produced by onion seeds treated with various insecticides and kept for 12 days in covered petri dishes after initial sprouting.

seeds except those treated with BHC. In this instance, the germination of seeds stored 0 days was similar to that for the checks. As the period of storage increased, the initial germination of the BHC-treated seeds decreased so that by 110 days after treatment all treated seeds had the same delay in germination.

Growth was apparently unaffected by the treatment of seed except in the case of BHC. In this treatment, although germination was significantly reduced, there were sufficient plants to observe its effect. Necrosis developed early, a factor found also by McLeod (1946) in his investigation on onion maggot control. J. R. Douglass and F. H. Shirck, U.S. Department of Agriculture, Twin Falls, Idaho (personal communication), found that wettable powder of lindane or chlordane applied to the seed trench at 0.46 or 1.4 pounds of active ingredient per acre, respectively, caused severe reduction in the onion stand; lindane caused 96.7 per cent. reduction, and chlordane 47.0 per cent. Although no serious effect on germination was observed for chlordane-treated seeds in the Kamloops tests, the necks of the bulbs were enlarged and chlorosis and necrosis appeared about the tenth day in the petri-dish tests.

SUMMARY

1. Germination of onion seed was adversely affected when the seed was treated with a wettable powder of DDT, BHC, dieldrin or toxaphene, or a 5 per cent. emulsion of aldrin, or a 5 per cent. emulsion of dieldrin. The solvent is suspected of being the toxic factor in the case of aldrin and dieldrin emulsions.

2. Growth of the onion plants, once the seed germinated, was not seriously affected by any of the treatments except that with BHC.

3. Storing of chemically treated onion seed in open glass dishes did not further seriously affect the eventual percentage germination, but it did delay germination.

ACKNOWLEDGMENTS

The author wishes to thank Dr. A. W. A. Brown, Head, Department of Zoology, University of Western Ontario, London, and Dr. R. H. Handford, Officer-in-Charge, Field Crop Insect Laboratory, Kamloops, for their very helpful suggestions. The work done during the winter of 1950-51 was done at the University of Western Ontario while the author was on a scholarship from the National Research Council of Canada and the remainder completed while employed by the Canada Department of Agriculture at the Kamloops laboratory.

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OBSERVATIONS ON THE STUDY OF BEETLES IN BRITISH COLUMBIA

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The study of the beetles or any other group of organisms in an area like British Columbia that was originally peripheral to the world centres of scientific study falls somewhat naturally into several periods. First there is a period of exploration, during which specimens are collected by itinerant scientific collectors and brought back to the centres of scientific activity where they are studied and reported upon. Eventually, however, itinerant collectors give way to resident collectors and the endemic study of the fauna gets under way. For long, however, the endemic collectors remain dependent on outside aid, and it is only gradually that fully endemic studies backed up by fully equipped museum and library facilities become established.

In British Columbia the first of the three periods in the study of the beetles was unusually transitory. The first beetles were not collected until about twenty-five years after the first specimens had been collected in the Oregon Country to the immediate south. In British Columbia, the first specimens to be taken seem to have been collected about the year 1859 to 1861 by the naturalists attached to the Anglo-American Northwest Boundary Commission. Dr. John L. LeConte of Philadelphia, the leading American student of the Coleoptera in the third quarter of the last century, records *Cicindela longilabris* Say and *Cupes serrata* LeC. in 1861 from "Camp Kootenay."[1] With lack of precision that is characteristic of the coleopterological work of the period, he failed to notice whether the "Camp Kootenay" referred to was the east crossing of the international border by the Kootenay River in Montana or its west crossing in Idaho. In either event, the specimens were as likely to have been taken on one side of the boundary line as on the other.

John Keast Lord, the British naturalist with the Commission in his *Naturalist in Vancouver Island and British Columbia,* 1866, refers to collecting beetles at least twice: once (Vol. II, p. 109) near Palouse-Falls in Washington, once (Vol. II, p. 123) along Slesse (Selece) Creek, a tributary of the Chilliwack River near Chilliwack. His list of 94 species of beetles published in an appendix[2] to his book, contains no intimation of localities. While some of the species listed probably were collected in British Columbia, others were not, and Lord is known to have travelled overland all the way from San Francisco to the Canadian border. His book shows him, moreover, to have been preoccupied with the vertebrates.

The real beginning of the scientific study of British Columbian beetles began with a collection made probably

1 New species of Coleoptera inhabiting the Pacific district of the United States. Proc. Acad. Nat. Sci. of Philadelphia 1861, pp. 338-359.

in the late sixties in "Vancouver Island and British Columbia" by Henry and Joseph B. Matthews, brothers of the Rev. Andrew Matthews, the British microclepidopterist. The collection which Henry Matthews, who was likewise a clergyman, brought back to England with him in 1869, was submitted by Andrew Matthews to LeConte. LeConte published a list of 186 species in the Annals and Magazine of Natural History in the same year. He considered British Columbia and Vancouver Island to be at that time the least explored portions of North America.[3] Notable among the new species described here was our famous ground beetle, *Zacotus matthewsii*. Three years later Andrew Matthews described two species of Amphizoa from the same source.[4]

Though George Robert Crotch collected beetles about Victoria and along the Fraser River in 1873, these remained the only significant publications on British Columbian beetles for fifteen years.

What I would call the period of resident collectors extends in British Columbia from about 1882, when George W. Taylor settled on Vancouver Island, to about 1919, when Ralph Hopping was called to Vernon. The principal Coleoptera literature, pertaining to the Province, that appeared during this forty year period consisted of about a dozen or fifteen separate short lists plus an annual listing, beginning in 1902, of 25 or 30 or more species in the Annual Report of the Entomological Society of Ontario.

The first endemic beetle work in the Province was Taylor's 1886 list in the Canadian Entomologist of 76 species of Cicindelidae and Carabidae from the vicinity of Victoria, named for him by Henry Ulke of New York. Lists by Brodie (1888) and Wickham (1893) represent the work of itinerant collectors. The most ambitious paper was the list of 241 species from Massett collected by the Rev. J. H. Keen, published in the Canadian Entomologist in 1895. The identification of Keen's specimens was arranged for by James Fletcher of Ottawa, Dominion Entomologist, who solicited the aid of numerous coleopterists in the eastern United States and Europe. A beginning at a Provincial list was made in 1906-1907 in the abortive Bulletin of the British Columbia Entomological Society, 154 species in Cicindelidae, Buprestidae, Coccinellidae, and Cerambycidae being listed. The status of the knowledge of the beetle fauna as a whole is suggested by the 800 species which in 1906, were stated by the Secretary of the Society, R. V. Harvey of Queen's School, Vancouver, to be in the provisional unpublished list of the Society.[5]

The local collectors were completely dependent on coleopterists residing for the most part in eastern Canada and northeastern United States for their determinations, and the westerners' contribution consisted almost exclusively in collecting material and transcribing the names assigned to it by others. There was no attempt at independent study because, as W. Downes explained to me some years ago, of the almost complete lack of basic literature. This was a lack which neither the public nor the private financial resources of the region was able to make good. In this connection, one notes the acknowledgment of A. H. Bush, in a 1914 list of 106 species from Mount Cheam, of the help in identification of Dr. E. C. Van Dyke of San Francisco. The endemic centres of beetle-study were beginning to close in on the Pacific Northwest.

Turning to the economic bases of the beetle studies of this period, one notes

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2 List of Coleoptera, Vol. II, pp. 309-334. The list was prepared by Francis Walker (1809-1874), entomologist at the British Museum, whose authorship is attested to on p. 290. For comments on this publication see LeConte, Ann. Mag. Nat. Hist. 4 (6), 1870, pp. 395, 399-402.

Another similar publication is LeConte, **List of Coleoptera**, Geol. Surv. Can. Rept. of Prog. 1875-76, 1877, pp. 107-109. 145 species are listed; but there is nothing to indicate which of the species were taken in British Columbia and where, and which, if any, were secured in Alberta or even further east!

3 See selected bibliography at end of paper for citation of this and other papers mentioned.

4 Descriptions of two new species of Amphizoa from Vancouver's Island: **A. josephi, A. Lecontei,** Cistula Entom. I, 1872, pp. 119-122. See likewise A. Matthews' obituary notice of the Rev. H. Matthews (d. 1874) in Ent. Mo. Mag. XIV, 1877, pp. 38-39.

with interest that the two first resident workers, Taylor and Keen, were clergymen. This is evidence of the British influence, for during the 19th century several of the most important British coleopterists were clergymen. One searches in vain for a clergyman advancing the study of beetles at this time in the United States. A. W. Hanham, who was contributing heavily to "The Entomological Record" during this period, was manager of the Bank of British North America in Duncan. R. V. Harvey, who was working on a Provincial list, was a school teacher. E. P. Venables was a farmer in the vicinity of Vernon. E. M. Anderson was connected with the Provincial Museum in Victoria. J. B. Wallis, public school teacher of Winnipeg, collected extensively at Peachland in 1909. A. H. Bush was an engineer on the Canadian Pacific Railroad. W. H. Brittain, who published a list of 73 species of Coleoptera from the Okanagan district in 1904 was employed in economic entomology.

In these tentative "Observations on the Study of Beetles in British Columbia," I should like to suggest that a new period in the study of the beetles of the Province dates from about 1920. The University of British Columbia was established in 1915. Entomology was first taught there in 1919, and Professor G. J. Spencer joined the staff of the institution as entomologist in 1924. Professor Spencer is not a coleopterist, and his beetle-studies have been confined to some of the household species. He has, however, laid the foundations for a Provincial collection, and the institution which he serves seems to furnish the condition under which we can expect that fully endemic beetle-studies can be carried on.

More important than the University of British Columbia as a centre of beetle-study, especially during the late twenties, is the Provincial Museum at Victoria, where G. A. Hardy has published a number of reports on the Elateridae, Buprestidae, and Cerambycidae of Vancouver Island. Mr. Hardy, however, serves the Museum as Botanist as well as Entomologist. While the Museum's beetle collection is extensive, as late as 1949, at any rate, it is badly in need of consolidation in modern insect boxes or drawers.

The most important beetle-studies to have been conducted in British Columbia in the past thirty years were those under the leadership of Ralph Hopping, 1868-1941, from 1919 entomologist in charge of the Dominion Forest Insect Laboratory at Vernon. Beginning in 1925, Mr. Hopping was assisted at the Vernon laboratory by his son, George R. Hopping, and beginning in 1930, by Hugh B. Leech, both of whom became interested in the taxonomy of the Coleoptera and both of whom remained connected with the Vernon laboratory for eight or nine years following Ralph Hopping's retirement in 1939. The Hoppings concentrated on the Cerambycidae, in which family they produced an important series of monographs,[6] but Ralph Hopping's studies in particular extended over the beetles as a whole. On September 1, 1938, his unpublished card index of British Columbia beetles numbered 2070 species, a figure to be compared with the 1906 figure cited above of 800 species, and indicating the growth of knowledge in the intervening period. The collection at Vernon came to number about 10,000 species in about 97,000 specimens, including large amounts of British Columbia material. In accordance with Ralph Hopping's own desire, his collection was sold for a nominal sum by his widow to the California Academy of Sciences in 1948, making that institution one of the most important repositories of British Columbia beetles.

5 Bull. Ent. Soc. B.C., No. 1, March 1906, p. 2. From 1901-1933 about 800 species of beetles were listed in the Coleoptera section of "The Entomological Record" which was published annually in the Annual Reports of the Entomological Society of Ontario from the 32nd Report for 1901, published in 1903, through the 61st Report of the Quebec Society for the Protection of Plants, published in 1934.

Hugh Leech specialized at first in both the Staphylinidae and the aquatic Coleoptera, later exclusively in the aquatic families. He has published a very extensive series of excellent short papers. In 1947, in order to secure the opportunity to concentrate on his taxonomic studies, he accepted the position of Associate Curator of Insects at the California Academy of Sciences, taking with him his collection of about 130 boxes of water beetles. With George Hopping's removal to Calgary the following year, the Vernon Group of coleopterists was dissolved.

A collector of beetles of some note in the vicinity of Terrace and Massett, in part some of the country formerly worked by the Rev. J. H. Keen, is Mrs. M. E. Clark of Terrace. As Mrs. W. W. Hippisley, she published some *Notes on Northern British Columbia Coleoptera* in the Canadian Entomologist (XLIV, pp. 63-66) in 1922. In 1948 and 1949 she published a list of 420 species of Cicindelidae through Coccinellidae in the Proceedings of our Society—the most extensive single list of species so far to have been published in British Columbia. Her specimens were named for her by C. A. Frost of Framingtham, Mass., who retained samples of most of her species, and she has recently deposited the residue of her collection at the University of British Columbia.

The leading presently active student of British Columbia beetles is Gordon Stace Smith, a mining foreman, now retired, of Creston. In 1929 and 1930, Stace Smith published a list of 323 species from Copper Mountain near Princeton, and he has one of the finest collections of the beetles of the Province ever assembled. Stace Smith represents the earlier collector-type of investigator, and he represents this type at its very best. An expert and indefatigable collector, he insists on the most precise preparation and labeling of every specimen. Each specimen, moreover, carries the names of the various coleopterists who have seen it and the names—not always congruent—that they have assigned to it. Stace Smith confines himself to the beetles of the Province, which he has represented in his collection in series up to 20 or 25 specimens of a species. At the end of 1950 he figured that he had representatives of a few over 2000 species of British Columbia beetles in his collection. He is, moreover, being of the utmost possible assistance to me in my work on *The Beetles of the Pacific Northwest.*

Finally, I have to mention Richard Guppy, of Wellington, near Nanaimo. Mr. Guppy confines his collection to Vancouver Island, and is proving very helpful in supplying material from that locality.

I now give some comparative figures on five collections of British Columbia beetles. In part I of my book, I recognize about 675 species of Northwestern beetles in the suborder Adephaga, which includes Carabidae, Dytiscidae, and related families. Of these 675 species, 511 are listed from British Columbia. Of these 511 species, I have found examples of 373 species in the collection of the California Academy of Sciences, 359 species in the collection of G. Stace Smith, 294 species in my collection at the University of Washington, 256 species in the collection of the University of British Columbia, and 157 species in the collections of the Provincial Museum at Victoria.*

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*Ed. Note.—Over 250 named species of this group are in the collection of the Vernon Forest Insect Laboratory.

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NOTES ON THE POPULATION AND PARASITISM OF THE LARCH SAWFLY, PRISTIPHORA ERICHSONII (HTG.) (HYMENOPTERA: TENTHREDINIDAE), IN BRITISH COLUMBIA[1]

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In British Columbia the larch sawfly, *Pristiphora erichsonii* (Htg.), was first reported in 1930 in an area about 30 miles north of Fernie. In 1933 a survey showed that the infestation covered a large area in and around Fernie. Cocoon samples were obtained at that time and were examined at the Forest Insect Laboratory, Vernon, B.C., and at the Dominion Parasite Laboratory, Belleville, Ont. No evidence of parasitism was found, and parasites were released in the infested area. The first colony of parasites, comprising 393 males and 280 females of *Mesoleius aulicus* (Grav.), was released in July, 1934, at Lizard Creek, 2 miles from Fernie.

P. erichsonii spread rapidly north and east following the distribution of western larch, *Larix occidentalis* Nutt., which, in the main, is confined to the southern interior of British Columbia. As parasites became available they were released in the newer areas of infestation to hasten establishment and distribution. Details concerning parasite releases and host distribution were given by Hopping, Leech, and Morgan (1943). At no time has *P. erichsonii* reached outbreak proportions in British Columbia except in isolated areas. The population in each of the heavily infested areas for which there are records became heavily parasitized by *M. aulicus* and subsided without serious injury to the trees.

In 1948 a project was initiated to provide colonies of *M. aulicus* from British Columbia for release in Western Ontario, Manitoba, and Saskatchewan. In that year 105,000 *P. erichsonii* cocoons, heavily parasitized by *M. aulicus*, were obtained. In 1949 one hundred and thirty thousand cocoons were collected. In 1950, after a thorough search of the infested area, only 2,500 cocoons were obtained. The numbers of cocoons collected in the 3 years do not accurately represent the change in population, but there was a reduction in 1950. All available data have been examined to determine the factor or factors responsible for the reduction in host population and its effect on *M. aulicus*.

In 1949 many of the larch trees in the infested area were affected with needle cast, the symptoms of which are a premature yellowing and early dropping of the needles. This caused some larval mortality during the feeding period, but no significant reduction in the number of cocoons collected in the most heavily infested area. It is possible that the viability of the larvae in the cocoons was reduced, but no evidence was obtained to support this theory. Emergence was normal from the 130,000 cocoons collected in October and November, 1949. and stored in an unheated laboratory room over winter, Random samples of cocoons taken from the 1948, 1949, and 1950 collections were dissected; the percentages of dead larvae were 16.5, 7.5, and 12.0, respectively (Table I). There was a decrease of 9.0 per cent. in larval mortality of *P. erichsonii* in 1949 rather than an increase, which would have occurred if needle cast had affected the viability of the larch sawfly larvae.

The winter of 1949-50 was unusually cold and a heavier-than-normal snowfall occurred. Weather records taken at the Grand Forks office of the Canada Department of Transport (14 miles from the infested area) show that the average temperature was below normal during the winter of 1949-50. On May 19, 1950, although much of the infested area was still covered with snow, a collection of cocoons was obtained. It was immediately

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placed in rearing at unheated room temperature (average, 62°F.) in Vancouver. The emergence from this collection was normal; therefore, it must be assumed that the reduction in population of *P. erichsonii* was not caused by winter mortality.

The next factor that was considered was parasitism. An increase in the percentage parasitism could have accounted for the decrease in the *P. erichsonii* population in 1950. However, there was a decrease in parasitism amounting to 6.7 per cent. (Table I).

TABLE I

Larval mortality, and parasitism, of *Pristiphora erichsonii* (Htg.) in British Columbia, 1948, 1949, and 1950.

	1948		1949		1950	
	Number	Per cent.	Number	Per cent	Number	Per cent.
Cocoons dissected	1464	100	536	100	441	100
P. erichsonii larvae dead (causes unknown)	248	16.5	40	7.5	53	12.0
living	1216	68.2	496	92.5	388	88.0
M. aulicus larvae living	829	83.5	305	61.5	213	54.9

Evidently, the mortalities caused by needle cast, winter weather, and parasitism were not responsible, individually or collectively, for the reduction in the population of *P. erichsonii* in 1950.

Finally, the diapause factor was considered. In British Columbia *P. erichsonii* normally completes its life-cycle in 1 year, but in 1950 there was evidence that a portion of the population remained in diapause. In September, 1950, the cocoons were most numerous in the area most heavily infested in 1949; previously, the centre of infestation had changed from year to year and had usually moved in a westerly direction. The cocoons were darker in colour than freshly formed cocoons normally are, and many of them were collected under trees from which cocoons had been taken in 1949. These trees showed fewer signs of larval feeding than would have been expected if the larvae that formed cocoons under them had fed on the 1950 foliage.

The first concrete evidence that some *P. erichsonii* remained in diapause throughout the summer of 1950 was found when the intact cocoons from a laboratory-reared collection were opened in August, 1950. There were 1,181 cocoons in the collection and of these 88, or 7.45 per cent., contained living *P. erichsonii* larvae. This percentage was not large enough to account for the important decrease in *P. erichsonii* population in 1950. During May and June, when normally diapause is broken and pupation occurs, the temperature in the laboratory was considerably higher than in the field. The average temperature in the laboratory was about 62°F.; at Grand Forks, which is about 1500 feet lower in elevation than the area of *P. erichsonii* infestation, the average temperatures during May and June were 51°F. and 61°F. respectively. The higher temperature in the laboratory could have been responsible for a smaller portion of the *P. erichsonii* larvae remaining in diapause in the laboratory than in the field.

TABLE II

Average weights of *P. erichsonii* cocoons in 3 size groups, 1949 and 1950.

Size of cocoons	1949		1950		Weight decrease, mg.
	Number	Average weight, mg.	Number	Average weight, mg.	
Large (10½ to less than 11½mm.)	145	86.2	113	83.5	2.7
Medium (9½ to less than 10½mm.)	170	73.6	229	69.2	3.4
Small (8 to less than 9½mm.)	221	55.5	99	50.9	4.6

If a large portion of the *P. erichsonii* larvae did in fact remain in diapause in the cocoons during the summer of 1950, it would be expected that the cocoons collected in the autumn of 1950 would be similar in weight and size to those that were collected in the autumn of 1949. There was no important difference in the weights of cocoons in the two years (Table II). The slight decrease that occurred in 1950 could have been caused by desiccation during the summer of 1950.

However, there was an important difference in the percentages of medium and small cocoons (Table III). There was a large increase in the percentage of medium and a large decrease in the percentage of small cocoons in 1950. This seemed to be irrefutable evidence that the cocoons collected in 1950 could not have been part of the 1949 population as they must have been if the larvae in them had remained in diapause.

TABLE III

Percentages of large, medium, and small cocoons of *P. erichsonii*, 1949 and 1950.

Size of cocoons	1949		1950	
	Number	Per cent.	Number	Per cent
Large	145	27.1	113	25.6
Medium	170	31.7	229	51.9
Small	221	41.2	99	22.4

An explanation for this anomaly was found when the rearing data were examined. The random collection from which the 88 larvae remaining in diapause were dissected was comprised of 1,181 cocoons, and from these 634 adults of *M. aulicus* and 309 adults of *P. erichsonii* were incubated. The numbers of each and the number of *M. aulicus* that remained in diapause are shown in Fig. 1, each plotted point representing the number of specimens for a 5-mg. group; *e.g.*, from cocoons weighing 46 to 50 mg.

4 adults of *P. erichsonii* emerged. It was seen that there was complete emergence from all cocoons that weighed less than 60 mg. and that the insects remained in diapause only in the larger and heavier cocoons. The largest numbers that remained in diapause were in the 75-mg. group. This corresponds closely with 73.6 mg., the average weight of the medium-sized cocoons in 1949 (Table II). If this occurred in the field, it would explain the reduction in the number of small cocoons and the increase in the number of medium-sized cocoons in 1950 (Table III).

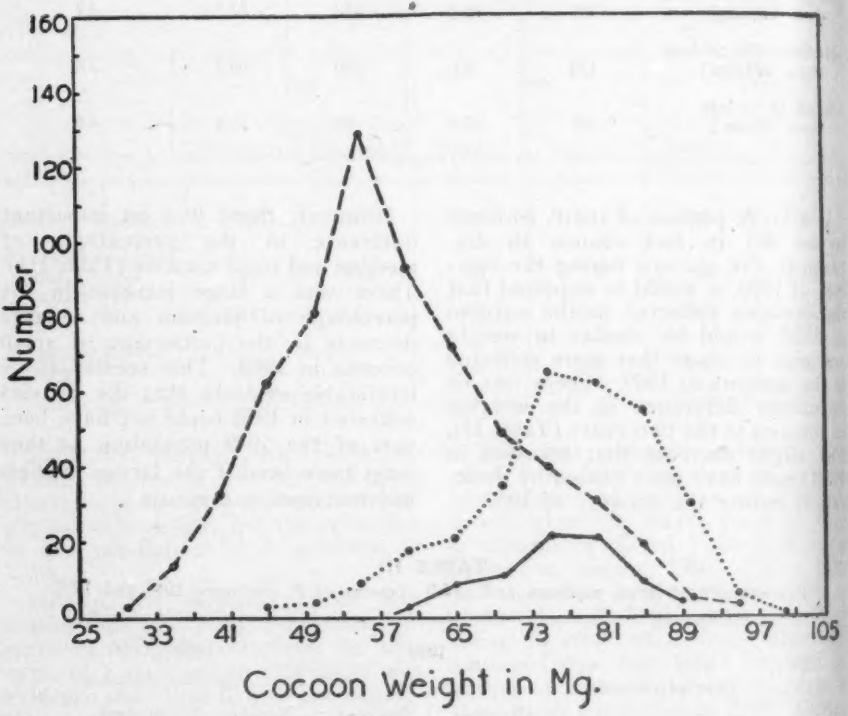

Fig. 1.—Numbers of adults of *Pristiphora erichsonii* (Htg.) (. . . .) and of *Mesoleius aulicus* (Grav.) (- - - -) that emerged, and numbers of larvae of *M. aulicus* remaining in diapause (————), from various weights of cocoons of *P. erichsonii* collected in British Columbia in 1949 and reared in 1950; each plotted point represents the number of specimens for a 5-mg. group, e.g., from cocoons weighing 46 to 50 mg. 4 adults of *P. erichsonii* emerged.

All the information obtained from field observation and laboratory rearing data supports the opinion that the reduction in abundance of *P. erichsonii* in 1950 was caused by a large portion of the population remaining in diapause. There was no evidence that needle cast, winter weather conditions, or parasites were responsible for the unusual population reduction.

Although parasites are not considered to have been responsible for the reduction in the population of *P. erichsonii* in 1950, they are an important control factor. This opinion is supported by the record of percentage

parasitism obtained by dissection (Table I) and by the proportion of *M. aulicus* adults that emerged from the random collection of 1,181 cocoons of *P. erichsonii* collected in 1949 and reared in 1950 (Fig. 1). Further evidence of the effectiveness of *M. aulicus* was obtained when the diapause *P. erichsonii* larvae were dissected in August, 1950; 89.8 per cent. of them contained living *M. aulicus* larvae. This showed that the parasite had synchronized its development with that of the host, thus ensuring the continued effectiveness of the parasite.

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BIOLOGY AND CONTROL OF THE CHERRY CASEBEARER, COLEOPHORA PRUNIELLA CLEMENS, IN BRITISH COLUMBIA[1]

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An outbreak of the cherry casebearer, *Coleophora pruniella* Clem., occurred in two adjacent apple orchards at Creston in the Kootenay Valley in 1947. This is the first record of this species for the Province of British Columbia. The insect was reported causing serious damage to apple at Salem, Oregon, in 1937, by Hsiao and Mote (1939), marking the most westerly record for this species. Known since 1861, when it was described, the cherry casebearer has been a serious pest of both cherry and apple in the United States and Canada during the past 25 years. Petch and Armstrong (1926) recorded that apple orchards in the Lake St. Louis area of Quebec had been heavily infested for several years. These authors were the first to give adequate descriptions of all stages of the insect and an adequate account of the life-history. Petch and Maheux (1930) reported little damage to apple in Quebec from this species, whereas 5 per cent. injury was caused by the cigar casebearer, *Coleophora occidentis* Zell. The latter species, the only casebearer hitherto recorded as having caused damage to orchards in British Columbia, was reported by Treherne (1914, p. 25) to be present in every orchard of the Lower Fraser Valley in 1912-13. Later Glendenning (1923) noted its presence in that valley but not as a serious pest. Hutson (1931, '32) reported the cherry casebearer to be a spectacular pest of cherry in Michigan. Its depredations in orchards were first noted in 1929, although known on wild black cherry from the time of its description.

LOCALITY, VARIETIES OF FRUIT ATTACKED, AND SEVERITY OF INFESTATION

The coleophorid infestation was confined to two adjacent orchards one mile southeast of Creston, at the southern end of the Kootenay Valley. One orchard contained only mature McIntosh apple trees, the other a mixed planting with McIntosh predominating but including Delicious, Jonathan, Winter Banana, and scattered pears and cherries. All fruit varieties were attacked, McIntosh most severely; the heaviest infestation and damage occurred in the orchard with the mixed planting. The difference in severity of damage between the two orchards was due to an application of dormant oil-dinitro orthocresol to the McIntosh planting but not to the mixed planting.

The infestation was first noted in the fall of 1947, when the twigs and fruit spurs were literally covered with overwintering cases. Evidently some damage had occurred in 1947 but had not been reported by the growers. In

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1948 the injury to the developing foliage was severe, approximately 60 per cent. of the leaves on some trees being almost completely skeletonized. Set, size, and colour of fruit were markedly affected. Late summer damage by young larvae was noticeable but not severe. Injury in 1949 was light, because of the application of a dormant spray in each orchard.

LIFE-HISTORY

The life-history of *C. pruniella* in the the Kootenays follows in general that related for Quebec (Petch and Armstrong, 1926), Michigan (Hutson, 1931), and Oregon (Hsiao and Mote, 1939). Dates noted in the developmental period refer to 1948 records.

Egg.—The eggs are light yellow, convoluted, and conoid; they are laid singly, usually on lower leaf surfaces in mid-July (July 12-23). As many as 60 eggs were observed on one leaf. Thirty leaves taken at random from lower portions of trees averaged 20 eggs per leaf. The incubation period was approximately 10 days. Petch and Armstrong (1926) reported 18 days as the average period of incubation for Quebec, whereas Hsiao and Mote (1939) reported 14 days for Oregon. All eggs hatched by August 10.

Larva. — Eclosion occurs through the base of the egg, so that the larva never exposes itself as it commences to mine the area between the upper and lower epidermal layers. The egg shell serves as a protection for the larva and for the storage of frass, while the larva gradually bores its way through the leaf tissues, forming a blotch mine around the egg shell. It continues to feed in the original mine for 3 to 3.5 weeks before forming a case and becoming mobile. The earliest cases were observed on August 16; forming of cases was complete by September 2. The larva moves frequently once the case is formed, tunnelling out a small, almost circular mine at each feeding site, so that the leaves become "peppered" with mines. After continuing to feed for 4 to 6 weeks the larva moves to a twig or spur, there to overwinter. Although feeding is prolonged over a 7-week period, mining is slow and larvae do not increase greatly in size. The original case is enlarged at least once. The overwintering cases are about 3.5 mm. long and 1.0 mm. in diameter. The majority of the larvae had moved to overwintering quarters by October 15. The larvae move from winter quarters at the end of April, when they attack the opening leaves. They feed for approximately 7 weeks, during which two additions are made to the cases. Mining is extensive during this period, and leaf injury may be severe, appearing as skeletonized dead and brown areas varying in shape and size. There was no yellowing or leaf drop as reported by Hutson (1931) in Michigan.

Pupation:—When mature, the larvae usually move to the twigs to pupate; some, however, remain attached to leaves and others lower themselves to the ground by silken threads and move to the tree trunks. The pupation period is about 10 days. Hsiao and Mote (1939) reported a pupation period of 3 weeks, but this record may refer to the period between cessation of feeding and moth emergence. About 2 weeks after the larvae cease feeding (about June 7) the moths emerge.

Adult.—In 1948, moths commenced to emerge on June 25 and continued until July 12, with the peak of flight about July 11. At this time hundreds of moths were noted in the cover crop and on the lower limbs of each tree. The moth population then gradually declined toward the end of the month. The first eggs were noted on July 12, the majority being laid by July 23.

CHEMICAL CONTROL

The normal spray schedule for apple scab and the codling moth, consisting of 4 to 5 sprays of lime-sulphur and calcium arsenate commencing in the pink stage of apple development, was of no value in controlling this pest. Additional sprays of lead arsenate and cryolite also failed to have any effect. Petch and Armstrong (1926)

and Hutson (1932) reported similar results with these materials. Treherne (1914), however, noted that lead arsenate applied before or after blossoming would control the cigar casebearer. Also, Gould (1936) reported control of the pistol casebearer, *C. malivorella* Riley, with lead arsenate. Hutson (1932) in Michigan, and Lilly and Fluke (1933, '34) in Wisconsin, reported effective control of the cherry casebearer with dormant oil 6 to 10 per cent. concentration. The latter authors found that a dormant lime-sulphur spray (1:8) in a fall application gave satisfactory control. The cigar casebearer, *Coleophora occidentis* Zell., in Norfolk County, Ontario, was not controlled with arsenicals, but dormant sprays of 1 per cent. "Elgetol" (20% dinitrocresol) or 0.5 per cent. "Elgetol" in 3 per cent. dormant oil emulsion gave excellent control (Hall, J. A., in litt., 1948). Of the chemical treatments applied at Creston, by far the most satisfactory was dormant oil, 2 gallons, and 40 per cent. dinitrocresol, 1.5 pounds, per 100 gallons of spray mixture.

NATURAL CONTROL

The egg, larval, and pupal stages of *C. pruniella* are known to be heavily parasitized. Petch and Armstrong (1926) reported 17 species of hymenopterous parasites in Quebec. Doner (1934) reared 32 species of parasites in Wisconsin; *Bracon pygmaeus* Prov., obtained from 70 per cent. of all parasitized larvae, was the most abundant. The same author (1936) recorded a long list of parasites, of which *B. pygmaeus* was again the most important. Total parasitism of mature larvae in Wisconsin ranged from 5 to 59 per cent. *Eurydinota lividicorpus* Gir. was the most common chalcidoid. Hsiao and Mote (1939) noted that these two parasites were important factors in the control of the pest in Oregon. Gould (1936) reared 36 species of parasitic Hymenoptera from the pistol casebearer, *C. malivorella* Riley; and later, Gould and Geissler (1940) reported a total of 40 species reared from the same host in West Virginia. Beacher (1947) recorded 15 species of parasites of *C. malivorella* in Pennsylvania and Delaware.

The species of hymenopterous parasites reared from the pistol casebearer are the same as those attacking the cherry casebearer. Indeed, some of these parasites, e.g., *E. lividicorpus,* attack only members of the genus *Coleophora.* The occurrence of this particular parasite in Creston indicates that the insect may have been present in that area for some time.

In 1948, some 500 encased larvae were collected from the infested Creston orchards in May and June. Five species of parasites were reared, including three chalcidoids and two ichneumonoids. The most abundant was the chalcid *Spilochalcis albifrons* (Walsh), which constituted 49 per cent. of the total. In 1949, 2,770 encased larvae were collected in May and July. Parasitism of larvae and pupae totalled approximately 15 per cent. and included 22 species, of which 16 were chalcidoids and the remainder ichneumonoids.

It was not possible to demonstrate the presence of egg parasites, although one such species, *Closterocerus* sp. near *tricinctus* (Ashm.). was reared from a mature coleophorid larva. The parasites reared may not all be primary parasites. Possible hyperparasitic species include *Gelis tenellus* (Say) and *Hypopteromalus percussor* Gir., although the former has been noted elsewhere as a primary parasite of *C. pruniella.* The limited number of individuals of some parasitic species suggests that their role as coleophorid parasites may have been accidental. The encyrtid *Copidosoma truncatellum* (Dalm.) is one of these. Three species, *G. tenellus, Closterocerus* sp. near *tricinctus,* and *Tetrastichus* sp., were found to have as alternate hosts two unidentified willow leaf miners. Examination of the figures for the relative abundance of the parasite species (Table I) indicates that the braconid wasp *Bracon pygmaeus* Prov. is the most important parasite of the cherry casebearer in Creston. *Tetrastichus* spp. and the chalcid *Spilochalcis albifrons* (Walsh) are next in importance.

TABLE I

Relative abundance of parasites of COLEOPHORA PRUNIELLA Clem. at Creston, B.C.

Species	Per cent. of total reared	
	1948	1949
Bracon pygmaeus Prov.	24.0	39.6
Tetrastichus sp.		12.6
Sympiesis sp. near *ancylae* Gir.		9.8
Spilochalcis albifrons (Walsh)	49.0	8.8
Hypopteromalus percussor Gir.		7.6
Gelis tenellus (Say)		7.1
Itoplectis obesus Cush.	14.0	5.5
Habrocytus thyridopterigis How.		3.5
Elachertus proteoteratis How.		1.3
Eurydinota lividicorpus Gir.		1.0
Closterocerus sp. near *tricinctus* (Ashm.)		0.5
Tetrastichus xanthops (Ratz.)	12.0	
Habrocytus phycidis Ashm.	1.0	
Other species (11)		2.7

A large number of the parasitic Hymenoptera reared from coleophorids at Creston are new records as casebearer parasites. However, the most important parasites, including *B. pygmaeus, S. albifrons, Tetrastichus* spp., *G. tenellus* and *E. lividicorpus,* are continentally widespread as parasites not only of *C. pruniella* but also of other coleophorids (Table 2).

LONGEVITY OF PARASITES

Studies were carried out on the longevities of some species of parasites reared from coleophorid larvae and pupae. Upon emergence from host cocoons, the parasites were transferred to shell vials, 5.5 inches in length and 1 inch in diameter, stoppered with corks. Dried raisins, pinned to the corks and wetted periodically, were supplied as food. Table 3 records the results.

TABLE II

Parasites of the Cherry Casebearer, COLEOPHORA PRUNIELLA Clemens, in British Columbia, and Records of Some of these Species from Quebec, Oregon, and the Pistol Casebearer, C. MALIVORELLA Riley

Species	Locality Host				
	British Columbia		Quebec*	Oregon**	*C. malivorella****
	1948	1949			
HYMENOPTERA					
CHALCIDOIDEA					
CHALCIDIDAE					
Spilochalcis albifrons (Walsh)	X	X			X
ENCYRTIDAE					
Copidosoma truncatellum (Dalm.)		X			
EULOPHIDAE					
Horismenus sp. near *fraternus* (Fitch)		X			
Elachertus proteoteratis How.		X			
Chrysocharis sp.		X			
Closterocerus sp. near *tricinctus* (Ashm.)		X			
Sympiesis sp. near *ancylae* Gir.		X			
Pnigalio sp. near *tischeriae* Ashm.		X			
Sympiesis sp.		X			X
Tetrastichus sp.		X			X
Tetrastichus xanthops (Ratz.)	X				
PTEROMALIDAE					
Catolaccus aeneoviridis (Gir.)		X			X
Eurydinota lividicorpus Gir.		X	X	X	X
Habrocytus phycidis Ashm.	X				X
Habrocytus thyridopterigis How.		X			X
Habrocytus sp.		X			
?Habrocytus sp.		X			
Hypopteromalus percussor Gir.		X			
ICHNEUMONOIDEA					
BRACONIDAE					
Bracon pygmaeus Prov.	X	X	X	X	X
ICHNEUMONIDAE					
Gelis tenellus (Say)		X			X
Itoplectis obesus Cush.	X	X			
Itoplectis quadricingulatus (Prov.)		X			
Scambus hispae (Harr.)		X			

* Petch and Armstrong (1926)
** Hsiao and Mote (1939)
*** Beacher (1947), Pennsylvania and Delaware; Gould and Geissler (1940), West Virginia.

TABLE III

Longevities of parasites of the cherry casebearer

Species	No. of individuals	Length of life in days		
		Maximum	Minimum	Mean
Bracon pygmaeus Prov.	20	77	5	36.9
Sympiesis sp. near *ancylae* Gir.	23	61	5	23.0
Spilochalcis albifrons (Walsh)	18	177	8	78.0
Gelis tenellus (Say)	8	81	8	50.4
Itoplectis obesus Cush.	10	33	1	16.8

The longest-lived of the parasites was *S. albifrons*, one specimen surviving for 177 days. The mean of 78.0 days is considerably higher than that of the next longest-lived species, *G. tenellus* (50.4 days). The maximum and mean longevities of *B. pygmaeus* (77 and 36.9 days) and *S. albifrons* (177 and 78.0 days) show a marked difference from the results found by Beacher (1947), who recorded 58.0 and 22.1 days for the former, and 10.0 and 8.0 days for the latter. Beacher used raisins for the food supply, but did not record supplying water, which may account for the differences.

ACKNOWLEDGMENTS

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EFFECTS OF LOW WINTER TEMPERATURES ON SOME ORCHARD MITES[1]

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INTRODUCTION

Many observations have been made on the effects of abnormally severe winters on the mortality of insects, but very few records have been noted of the influence of such climatic conditions on the development of orchard mites. Yothers (1917), in discussing the effects of the freeze of February 2-4, 1917, upon citrus pests in Florida, stated that the rust mite, *Eriophyes oleivorus* Ashm., was nearly exterminated in those areas in which the minimum winter temperature varied from 15 to 20°F. Adults of the citrus red mite, *Paratetranychus citri* (McG.) [*Tetranychus citri* McG.,], were not affected, but the eggs were thought to have been killed, as the pest was not abundant the following summer. The mite *Tenuipalpus bioculatus* McG. was slightly reduced in number, but *Tetranychus yothersi* McG. appeared to have been seriously affected. Several other authors have published accounts of the influence of climatic factors on mite development, but these have been mainly concerned with the effects of summer temperatures on abundance.

The observations reported here were made in the Okanagan and Kootenay valleys of British Columbia during 1950, immediately after the coldest winter on record in Western Canada. Temperatures during November and December, 1949, did not fall below zero, but mean temperatures for December were one to four degrees below normal in the southern interior of the Province. Below-zero temperatures were common throughout January and the first few days of February, 1950. Records kept at the Summerland laboratory showed that these temperatures occurred in three cycles; the first from January 2 to 4 (minimum −9.0°F.), the second from January 13 to 18 (minimum −8.8°F.), and the third from January 24 to February 3 (minimum −15.9°F.). Minimum winter temperatures recorded at official weather stations were: −23°F. at Oliver, −16°F. at Penticton, −24°F. at Kelowna, −32°F. at Vernon, −37°F. at Kamloops, −16°F. at Nelson, and −20°F. at Creston. These temperatures were 15 to 20 degrees below normal in the interior valleys immediately north of the International Boundary (Boughner, 1950). As a result orchard trees of all types were severely damaged throughout the Okanagan Valley. In addition it might be expected that such abnormally low temperatures would have a detrimental effect on the invertebrate fauna of the orchards. It was the purpose of the investigation to determine the effects of the sub-zero temperatures on the mortalities of the overwintering forms of the following orchard mites: the European red mite, *Metatetranychus ulmi* (Koch); the two-spotted spider mite, *Tetranychus bimaculatus* Harvey; the Pacific mite, *Eotetranychus pacificus* (McG.); and *Eotetranychus flavus* (Ewing), known to growers as the yellow Willamette mite.

METHODS

Samples of overwintering mites were collected from the latter part of February to the end of April, 1950. Where possible these collections were made from a number of areas to obtain material subjected to various minimum winter temperatures. The minimum temperature given for each collection site was based largely on a compromise of records from a number of household thermometers and the nearest weather station, since the collection locale was often many miles from an official station.

European red mite mortality was determined by placing the spurs or twigs containing the winter eggs in

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TABLE I

Percentage Survival of European Red Mite Winter Eggs Subjected to Various Minimum Winter Temperatures and Incubated at 65, 75, or 85°F.

Area	Minimum winter temperature, °F.	Incubation temperature °F.	Eggs in sample	Survival per cent.
Nelson	—18	65	242	68.6
		75	453	62.3
		85	248	52.8
Oliver	—23	65	305	54.1
		75	102	46.1
		85	223	39.9
Vernon	—32	65	3079	15.8
		75	2674	12.6
		85	2542	10.4
Salmon Arm	—30 to —35	65	294	0.0
		75	500*	0.0
Salmon Arm	—35 to —38	65	489	0.0
		75	500*	0.0
Salmon Arm	—40	65	2500*	0.0

* Estimated

a constant temperature cabinet and incubating the eggs until they hatched. The eggs were incubated at 65, 75, or 85°F. and at a relative humidity of approximately 80 per cent.

The two-spotted spider mite, the Pacific mite, and the Willamette mite winter as mature females, generally in colonies under the bark scales of scaffold limbs and the trunk, and under fallen leaves and debris on the ground around the tree base. Mites that hibernate in the latter site obtain extra protection from cold by snow coverage. Accordingly, two samples of infested bark scales were taken at each collection point, one above snow line and the other below. These samples were gradually warmed to room temperature, and mortality was determined by comparing the numbers of living and dead mites. Only one collection of the Willamette mite was obtained, as at that time this mite was not known to occur in large numbers except in one orchard.

RESULTS

Differences in the survival of the European red mite winter eggs subjected to various low winter temperatures are shown in Table I. Between 52.8 and 68.6 per cent. of the eggs survived a temperature of −18°F. Where −32°F. was experienced, only 10.4 to 15.8 per cent. of the eggs remained alive. No larvae could be reared from eggs collected in the Salmon Arm area, where temperatures of −30 to −40°F. were common. The results indicated that all winter eggs of the European red mite would be killed by a minimum temperature between −32 and −35°F. and that this might be the minimum isotherm that could determine the possible northern limit of existence of this mite. Subsequent field observations, however, proved that this was not the case. Although the European red mite could

not be found in the Salmon Arm orchards in June or July, 1950, several specimens were observed in August, and by the spring of 1951 it was common enough that control measures would probably be required sometime during the year. In the Okanagan Valley, the European red mite was not particularly troublesome in 1950, but this may have been due to the application of the parathion "pink" spray, which gave excellent control in the majority of orchards for the remainder of the season.

The results also indicate that a relatively cool spring may be more conducive to the occurrence of large populations of the European red mite than very warm weather when winter eggs are incubating. Fewer larvae were obtained when the eggs were incubated at 85°F. than at 75 or 65°F.

Mites that overwinter in the adult stage appear to be less resistant to extremely low temperatures than those, such as the European red mite, that overwinter as eggs. Of the three mites investigated that winter in the adult stage, the two-spotted spider mite may be the hardiest: 37.2 per cent. survived a temperature of −23°F., whereas only 5.6 to 6.2 per cent. of the wintering adults of the Pacific mite remained alive after being exposed to −22°F. and less than one per cent. of the adults of the Willamette mite survived a temperature of −20°F. Table II demonstrates the value of the protection offered by the snow cover, the survival being much higher below than above the snow line.

TABLE II

Percentage Survival of the Two-spotted Spider Mite, the Pacific Mite, and the Willamette Mite Subjected to Various Minimum Winter Temperatures.

Mite	Area	Minimum winter temperature °F.	Collection above or below snow line	Winter adults in sample	Survival per cent.
Two-spotted spider mite	Oliver	—23	above	3839	37.2
			below	1676	46.0
	Salmon Arm	—30	above	3000*	0.0
			below	457	31.3
	Kamloops	—37	above	3000*	0.0
Pacific mite	Summerland	—22	above	839	6.2
			above	1816	5.6
	Kelowna	—25	above	282	0.0
			below	220	41.8
	West Summerland	—30	above	2000*	0.1
			below	2593	35.1
Willamette mite	Summerland	—20	above	5000*	0.1
			below	5973	14.6

* Estimated

Although these three pests were greatly reduced in numbers in many areas, the reduction was not sufficient to be of economic importance to the fruit grower. In 1950, the two-spotted spider mite did more damage in the Okanagan Valley than at any time previously; severe infestations were very common from Penticton north to Salmon Arm. Pacific mite populations were slightly larger than in 1949, and medium to severe infestations occurred in several orchards. The Willamette mite, which was found in the fall of 1949 at Summerland for the first time in the Province, occurred throughout the Valley from the International Boundary north to Kamloops. Severe infestations developed in a number of orchards.

SUMMARY

In the British Columbia fruit- growing area the coldest winter on record occurred in 1950. Temperatures of −15 to −15°F. were common. This was 15 to 20 degrees below normal.

Field collections of the overwintering forms of the European red mite, the two-spotted spider mite, the Pacific mite, and the Willamette mite were made from the latter part of February to the end of April, 1950, to determine the effects of the low winter temperatures. Practically 100 per cent. of the European red mite winter eggs were killed in the Salmon Arm area, where temperatures of −30 to −40°F. were common. The European red mite was not found in this area until August, 1950, but by the spring of 1951 it was common enough that control measures were necessary. The two-spotted spider mite appeared to be the hardiest of the three forms that winter as adults. Although these three mites were greatly reduced in numbers by the cold winter, summer populations were larger during the growing season of 1950 than in 1949.

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A PRELIMINARY LIST OF THE HEMIPTERA OF THE KOOTENAY VALLEY[1]

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INTRODUCTION

Studies to determine the insect vector or vectors of the little cherry virus disease in the Kootenay Valley were carried out during the seasons of 1946-49. As part of the investigation a survey was made of the insects occurring on sweet cherry and other host plants common in the Valley. Although all orders of insects were collected, little interest was taken in other than the Hemiptera, since nearly all the virus vectors known belong to that order. The accompanying list forms only part of the total.

METHODS, HOSTS, AND COLLECTION AREA

Collecting was done by various means: (1) a sweeping net, (2) knockdown sprays and a large canvas ground sheet, (3) a hand suction apparatus, and (4) 6-inch-by-12-inch plywood boards coated with "Deadline" tanglefoot on one surface and hung by wire loops in tree or shrubs. The last-named method proved highly satisfactory and yielded species that were not taken from the same hosts by any other means. There was some difficulty in removing the tanglefoot from the specimens. The most successful procedure involved placing a drop of kerosene on each specimen, which was then loosened and removed from the board with dissecting

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needles and placed in a small beaker of kerosene. The beaker was warmed; the contents were gently swirled, and filtered through a number 4 Whatman filter paper. The insects were removed from the filter paper and placed in petroleum ether, gently swirled, and poured on to a dry filter paper. The petroleum ether quickly evaporated, and then the specimens were mounted or stored. Sometimes while the insects were in the kerosene and/or petroleum ether it was necessary to use fine dissecting needles to tease out large masses of the tanglefood trapped in the legs. The tanglefood collecting method was useful for most Hemiptera and Coleoptera, and some Diptera and Hymenoptera.

Regular collections were made from the following hosts throughout the growing season: sweet cherry, *Prunus avium* L.; wild cherry, *Prunus emarginata* (Dougl.) Walper var. *mollis* (Dougl.) Brewer; apple *Pyrus malus* L.; wild rose, *Rosa nutkana* Presl.; thimbleberry, *Rubus parviflorus* Nutt.; willow, *Salix* sp.; poplar, *Populus trichocarpa* T. & G.; red clover, *Trifolium pratense* L.; alfalfa, *Medicago sativa* L.; and cover crops: mixed grasses, clovers, and alfalfa.

Collections were made in the area limited by Creston, at the south end of Kootenay Lake; Kootenay Bay, 50 miles north, on the east side of the lake; Nelson, 50 miles north and 30 miles west, on the west arm of the lake; and Kaslo, 80 miles north, on the west side of the lake. Collections in 1946 were made by Mr. Harry Andison of the Fruit Insect Laboratory, Victoria, British Columbia.

DESIGNATION OF PLANT "HOSTS"

The indiscriminate usage of the term *host* has been the bane of taxonomists for some time, particularly in the Heteroptera and Homoptera. In the accompanying list the plant-insect relationship is designated as follows: where no symbol is given, the plant listed is one on which the insect species was collected, and does not imply a food or host-plant relationship. H (host) indicates a plant in which eggs were deposited and on which nymphal development occurred. F (food plant) indicates a plant known to be utilized as a source of food by adults. The additional symbol *Test* indicates that the insect species survived on sweet cherry, at least during the experimental period in vector feeding tests.

Acknowledgments

The writer is indebted for determinations as follows:—Heteroptera: Dr. R. I. Sailer, U.S. Department of Agriculture, Washington, D.C.; Homoptera (other than Cicadellidae): Miss L. M. Russell, U.S. Department of Agriculture, Washington, D.C.; Cicadellidae; Dr. P. W. Oman, U.S. Department of Agriculture, Washington, D.C., and Dr. D. J. Knull, Ohio State College, Columbus, Ohio.

TABLE I

HOMOPTERA

Insect Species	Collection Source
CICADELLIDAE	
Agallia quadripunctata (Prov.)	cover crop
Aceratagallia californica (Baker)	sweet cherry
Oncopsis pruni (Prov.)	cover crop, flying near willow
Oncopsis spp. (two)	flying near willow
Idiocerus spp. (two)	on cages surrounding test trees
Idiocerus spp. (five)	willow
Gyponana angulata (Spbg.)	cover crop
Gyponana serrata DeL.	thimbleberry, willow
Aphrodes albifrons (L.)	thimbleberry, poplar, cover crop, sweet cherry. Test
Aphrodes costata (Panz.)	cover crop, sweet cherry, thimbleberry
Draeculacephala sp.	cover crop
Neokolla hieroglyphica (Say)	cover crop
Dikraneura absenta DeL. & C.	sweet cherry, F; cover crop, F; poplar. Test
Dikraneura carneola (Stal)	sweet cherry. Test

Dikraneura sp., prob. *carneola* (Stal)	cover crop
Dikrella cruentata Gill.	sweet cherry, F; thimbleberry, F. Test
Empoasca atrolabes Gill.	thimbleberry
Empoasca incida DeL.	willow, poplar
Empoasca maligna Walsh	sweet cherry, H; cover crop. Test
Empoasca deluda DeL.	cover crop
Empoasca sp. near *vincula* DeL.	wild cherry, sweet cherry . Test
Empoasca sp.	thimbleberry
Empoasca sp.	sweet cherry
Typhlocyba ariadne McA.	sweet cherry, F; cover crop; willow; thimbleberry. Test
Typhlocyba commissuralis Stal	willow. Test
Typhlocyba pomaria McA.	sweet cherry, H; wild cherry; cover crop. Test
Typhlocyba prunicola Edw.	sweet cherry
Typhlocyba rosae (L.)	wild rose, H; sweet cherry, H. Test
Typhlocyba sp.	sweet cherry, willow. Test
Typhlocyba sp.	sweet cherry, thimbleberry
Typhlocyba sp.	sweet cherry
Erythroneura sp. near *acicularis* Beam.	wild cherry. Test
Erythroneura aspera B. & G.	sweet cherry, F. Test
Erythroneura insigna B. & G.	sweet cherry. Test
Erythroneura plena Beam.	wild cherry, H; sweet cherry, F. Test
Erythroneura sp. *obliqua* group?	sweet cherry
Erythroneura sp.	sweet cherry, F; wild cherry. Test
Erythroneura sp.	wild cherry. Test
Erythroneura sp.	willow. Test
Scaphytopius acutus (Say)	thimbleberry, poplar, cover crop, sweet cherry. Test
Scaphytopius oregonensis (Baker)	sweet cherry
Balclutha punctata (Thumb.)	sweet cherry, cover crop. Test
Macrosteles divisus (Uhl.)	sweet cherry, cover crop. Test
Osbornellus borealis DeL. & M.	willow, sweet cherry
Colladonus flavocapitatus (Van D.)	poplar, wild cherry
Colladonus geminatus (Van D.)	cover crop; alfalfa, F; sweet cherry. Test
Colladonus montanus (Van D.)	cover crop; F; sweet cherry. Test.
Idiodonus cockerelli (Ball)	sweet cherry
Twiningia pellucida (Ball)	willow
Fitchana twiningi (Uhl.)	willow
Paraphlepsius bifidus (S. & DeL.)	sweet cherry
Euscelidius schenkii (Kbm.)	cover crop; red clover, F
Scleroracus sp.	cover crop. Test
Exitianus exitiosus (Uhl.)	sweet cherry, cover crop. Test
Psammotettix affinis (G. & B.)	sweet cherry
Psammotettix sp.	cover crop
Sorhoanus flavo-virens (G. & B.)	cover crop
Latalus sp.	cover crop
DELPHACIDAE	
Delphacodes consimilis (Van D.)	cover crop
Delphacodes pellucida (F.)	cover crop
Delphacodes sp.	cover crop
CERCOPIDAE	
Philaenus leucophthalmus (L.)	sweet cherry; cover crop, H; thimbleberry; wild cherry. Test
Aphrophora permutata Uhl.	cover crop, on cages enclosing cherry trees
Clastoptera obtusa var. *tristis* Van D.	willow
PSYLLIDAE	
Psylla trimaculata var *astigmata* Crawf.	sweet cherry, F; willow; wild cherry, F. Test
Aphalara persicaria Cald.	cover crop
CICADIDAE	
Platypedia areolata (Uhl.)	sweet cherry, on cages enclosing cherry trees
Okanagana vanduzeei Dist.	sweet cherry
MEMBRACIDAE	
Telamona pyramidata Uhl.	willow

APHIDIDAE
Myzus cerasi (F.) — sweet cherry, H. Test

COCCIDAE
Phenacoccus aceris (Sign.) — sweet cherry, H; apple, H. Test

HETEROPTERA

TINGIDIDAE
Corythucha mollicula O. & D. — willow, F. Test

PENTATOMIDAE
Euschistus variolarius (P.B.) — cover crop, on cages enclosing cherry trees. Test
Cosmopepla bimaculata (Thom.) — cover crop. Test
Eurygaster alternatus (Say) — cover crop
Meadorus lateralis (Say) — thimbleberry, willow

ARADIDAE
Aradus funestus Bergr. — on cages enclosing cherry trees
Aradus inornatus Uhl. — on cages enclosing cherry trees
Mezira pacifica Usinger — on cages enclosing cherry trees

NABIDAE
Nabis alternatus Parsh. — cover crop
Nabis rufusculus Reuter — cover crop

LYGAEIDAE
Stignocoris rusticus (Fall.) — sweet cherry, cover crop. Test
Kleidocerys franciscanus Stal — cover crop
Kleidocerys resedae (Panz.) — on cages enclosing cherry trees

MIRIDAE
Stenotus binotatus (F.) — cover crop
Miris dolobratus (L.) — cover crop
Stenodema virens (L.) — cover crop
Capsus ater (L.) — cover crop
Lygus hesperus Knight — cover crop
Lygus elisus Van D. — cover crop
Lygus shulli Knight — cover crop, H; wild cherry. Test
Lygus ceanothi deleticus Knight — thimbleberry
Lygus sp. — sweet cherry
Deraeocoris fasciolus Knight — sweet cherry. Test
Deraeocoris sp. — sweet cherry
Phytocoris interspersus Uhl. — willow
Phytocoris hesperus Knight — poplar
Plagiognathus obscurus Uhl. — cover crop
Plagiognathus chrysanthemi (Wolff) — cover crop
Hyaliodes harti Knight — willow, sweet cherry, cover crop. Test
Diaphnidia pellucida Uhl. — willow
Dicyphus sp. — thimbleberry. Test
Pilophorus sp. — willow

Summary

A preliminary list of 108 species of Hemiptera collected in the Kootenay Valley of British Columbia from 1946 to 1949 is recorded. These include 63 species of Cicadellidae, 3 of Delphacidae, 3 of Cercopidae, 2 of Psyllidae, 2 of Cicadidae, 1 of Membracidae, 1 of Aphididae, 1 of Coccidae, 1 of Tingidae, 4 of Pentatomidae, 3 of Aradidae, 2 of Nabidae, 3 of Lygaeidae, and 19 of Miridae.

A MODEL PROBLEM IN INSECT ECOLOGY

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During the course of its life cycle, every insect encounters a number of crucial trials which it must pass if the species is to survive. These trials concern three important life activities, namely, reproduction, development and survival. A species must maintain a sufficient reproductive output, develop at a sufficient rate, and have enough survivors if it is to remain in existence. Ordinarily a species occurs in somewhat greater abundance than the mere minimum for its survival. It exists in dynamic balance, decreasing under adversity, and increasing when conditions are especially favorable. Different environments provide conditions ranging from those which prohibit the existence of a given insect species, to those permitting great outbreaks.

Among the problems of insect ecology are those concerned with explaining why certain insects produce outbreaks, yet others in the same locality and even feeding on the same host do not. Another problem concerns the reason why certain areas experience the increase in insect population while others do not. The lodgepole pine needle miner (*Recurvaria milleri* Busck) provides an excellent opportunity for enquiry into these outbreak problems.

The lodgepole pine needle miner had not been known in the Canadian Rockies until 1942. In that year, its injury to the needles resulted in discoloration of a small area of forest near Banff. This heralded the beginning of an outbreak which increased in extent and severity until it covered an area of about 400 square miles, involving Banff, Kootenay, Yoho and Jasper National Parks. Great concern arose over the possible extension of the infestation into the pine stands of the East Slope watershed. The loss of those stands could be calamitous to communities far along the rivers that have their origin in the mountains.

Certain basic questions arise over this problem. Why did the outbreak develop where and when it did? Can the infestations spread from epidemic centres, or do they develop autochthonously from endemic populations? Are the East Slope forests really in danger from spread of outbreaks or build-up from endemic populations? These problems are all open to investigation by considering the particular crucial trials that the needle miner must encounter. And now, what are these trials?

The crucial part in the life of a needle miner begins in the food reserves carried into the pupal stage from the larva. The ultimate egg output depends firstly upon the quantity and quality of the food on which the larvae feed. The quality of food must vary according to numerous factors affecting the growth of the tree. Age of trees, soil, soil moisture, aspect, altitude, injuries, all varying locally and regionally, may have an influence on the food quality of foliage, and thereby affect the storage of materials for eventual egg production in the insect.

The next trial in the life of the insect-to-be is the successful pupation of the larva containing the future egg-forming substances. Conditions of environment determine the proportion of individuals that can complete the transformation. Of these conditions, temperature and humidity are probably the most important. Some seasons and some areas may be more favorable or less so than others. The needle miner in the Canadian Rockies passes through a long pupal period during the hottest and driest part of the year. In the dry hollowed-out needle the pupa, though partially protected, is nevertheless exposed to desiccation and high temperature, for a period of up to six weeks. This stage is important in many Lepidoptera as the period when the ovaries are developed and oogenesis takes

place. Desiccation during this period can greatly reduce the egg potential. It is conceivable that only certain areas, in certain years, provide conditions favorable to this process. This suggests the problem of determining the effect of environments in the non-infested areas to find whether or not they provide conditions favorable to egg formation.

The pupal stage is beset with other hazards to survival at that time, the principal ones in the needle miner being parasites and birds. As another obstacle at the time of emergence, the adult may be unable to free itself from the pupa or needle containing it. Here again atmospheric moisture conditions may be influential.

The eggs developed in the female must be fertilized if they are to hatch. The process of mating in Lepidoptera meets with maximum success only within rather narrow limits of temperature, humidity, light and air movement. Under adverse environmental conditions, low fertility may result. Here is another problem for study.

Next, the fully formed, fertilized eggs, contained in the female, must be successfully laid. For this, the female must live a sufficient length of time and she must experience suitable environmental conditions in order to lay them. Adverse temperature, and humidities during this period may cause a failure of the population in most areas and in most years. The eggs of the needle miner in the Canadian Rockies are almost exclusively laid within the cavity of the dry needles mined out during previous larval feeding. Here the delicate eggs are moderately well protected from mechanical damage, but not entirely from desiccation and heat. The success in hatching may thus vary locally, regionally and seasonally.

When the larva has issued from the egg, it must crawl from the old mined-out needle to seek the foliage of the current season's growth. Then, having found suitable needles, it must bore through the epidermis to find food and relative security. In this process of locating its food, the larva must overcome the trials of establishment during late summer and early fall. In the needles, the larva feeds during autumn as long as temperature permits. Under continually falling temperatures it apparently enters an induced diapause, in which state it does not respond readily to warming. During the winter months it is subjected to intense cold, sometimes of considerable duration, depending on the locality, altitude, and inflow of Chinook winds. Towards spring it may be subjected to early warming and partial activation, followed by sub-zero temperatures. Severe conditions between autumn and spring result in drastic reductions in needle miner populations. The degree of mortality varies according to locality and altitude. There appears to be less mortality in valleys where premature spring warming does not occur. There is also less killing at a certain elevation above the valley floor, the reason probably being the presence of a warmer thermal layer during winter cold. It is probable that certain areas never provide winter conditions permitting population build-up of this insect.

Finally, during a first summer of larval development, the needle miner is attacked by parasites, diseases and birds. Then it is exposed to a second winter of cold and a second summer of attack by natural enemies before it finally pupates. It is evident that the needle miner must pass the test of numerous critical conditions if it is to increase or even merely survive. Some areas, we know, provide conditions which, on occasion, permit population increase. Other areas probably are always unfavorable in at least one respect. In those areas, epidemics may never occur, regardless of the presence of an endemic population, and despite contagious tendencies of populations in adjacent areas. It may well be asked if perhaps the East Slope of the Rockies is too dry and hot during the reproductive period of the insect, and too cold or changeable during the overwintering stage of the larvae.

The needle miner therefore offers many interesting and productive ecological problems. It is especially convenient for study because, in the needle, the larva possesses relative fixity of abode, and thereby is amenable to refined sampling methods. With pine as a host, it is possible to estimate the number of miners per branch tip, the number of branch tips per tree of various heights, and the number of trees of various sizes per acre. From these data a population census of the insect has been possible. Applying percentage figures for parasitism, it has been possible to determine the number of parasites per acre.

This insect is therefore an eminently suitable one for developing population sampling statistics. The acquisition of reliable procedures for taking stock of populations will be of material assistance in measuring the influence of various factors. Nevertheless, after many decades of entomological progress, in this case we cannot do better than turn to the insect itself for the real answers to some of the most far-reaching problems.

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ERRATA VOL. 47, 1951

Page 4, line 27—for IXODIAE read IXODIDAE

Page 30, lines 8, 11 and 16—the names *Ascogaster quadridentata, Bessa harveyi* and *Bigonichaeta setipennis* are misplaced and the upper half of the table should read as follows:—

SPECIES	HOST	LOCALITY	YEAR	ORIGIN	NUMBER RELEASED
Ascogaster Carpocapsae (Vier.)		South Okanagan	1937	"	291
		Vernon	1937	"	725
		Victoria	1937	"	560
		Winfield	1937	"	2,845
		Victoria	1939	"	570
		Vernon	1939	"	33,250
	Pea moth. *Laspeyresia nigricana* (Steph.)	Chilliwack	1936	Ontario	300
		Sumas Prairie	1936	"	966
		East Chilliwack	1937	"	50
Ascogaster quadridentata Wesm.	Pea moth. *Laspeyresia nigricana* (Steph.)	Sumas Prairie	1937	England	34
		Chilliwack	1938	"	127
		Musselwhite	1938	"	753
		Chilliwack	1939	"	4,377
		Cloverdale	1947		3,592
Bessa harveyi (TT) *selecta* Mgn. of American auth.)	European larch sawfly *Pristiphora erichsonii* (Htg.)	Edgewood	1942	New Brunswick & Ontario	3,750
		Vernon	1942	"	2,245
Bigonichaeta setipennis (Fall.)	European earwig *Forficula auricularia* (L.)	New Westminster	1928	England & U.S.A.	165
		New Westminster	1929	"	212
		New Westminster	1930	"	326
		New Westminster	1931	"	373

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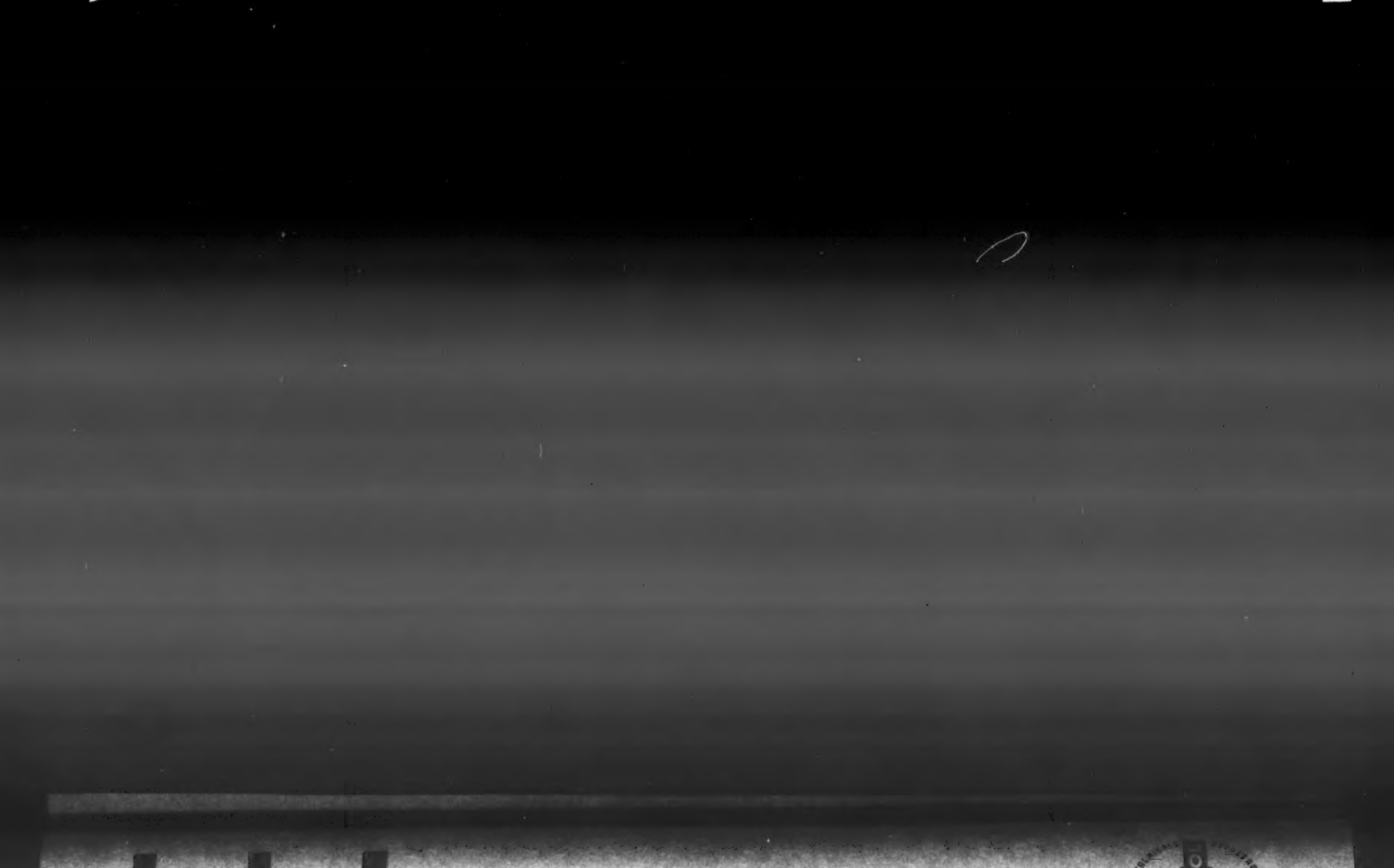
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